PHILOSOPHICAL

TRANSACTIONS,

OF THE

ROYAL SOCIETY

OF

LONDON.

FOR THE YEAR MDCCXCIII.

PART I.

LONDON,

SOLD BY PETER ELMSLY,
PRINTER TO THE ROYAL SOCIETY.
MDCCXCIII.

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PRINTED BY TAYLOR AND WILSON,
PRINTERS TO THE ROYAL SOCIETY.
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ADVERTISEMENT.

THE Committee appointed by the *Royal Society* to direct the publication of the *Philosophical Transactions*, take this opportunity to acquaint the Public, that it fully appears, as well from the council-books and journals of the Society, as from repeated declarations which have been made in several former *Transactions*, that the printing of them was always, from time to time, the single act of the respective Secretaries, till the Forty-seventh Volume: the Society, as a Body, never interesting themselves any further in their publication, than by occasionally recommending the revival of them to some of their Secretaries, when, from the particular circumstances of their affairs, the *Transactions* had happened for any length of time to be intermitted. And this seems principally to have been done with a view to satisfy the Public, that their usual meetings were then continued, for the improvement of knowledge, and benefit of mankind, the great ends of their first institution by the Royal Charters, and which they have ever since steadily pursued.

But the Society being of late years greatly enlarged, and their communications more numerous, it was thought advisable, that a Committee of their members should be appointed to reconsider the papers read before them, and select out of them such as they should judge most proper for publication in the future *Transactions*; which was accordingly done upon the 26th of March, 1752. And the grounds

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of their choice are, and will continue to be, the importance and singularity of the subjects, or the advantageous manner of treating them; without pretending to answer for the certainty of the facts, or propriety of the reasonings, contained in the several papers so published, which must still rest on the credit or judgment of their respective authors.

It is likewise necessary on this occasion to remark, that it is an established rule of the Society, to which they will always adhere, never to give their opinion, as a Body, upon any subject, either of Nature or Art, that comes before them. And therefore the thanks, which are frequently proposed from the Chair to be given to the authors of such papers as are read at their accustomed meetings, or to the persons through whose hands they receive them, are to be considered in no other light than as a matter of civility, in return for the respect shewn to the Society by those communications. The like also is to be said with regard to the several projects, inventions, and curiosities of various kinds, which are often exhibited to the Society; the authors whereof, or those who exhibit them, frequently take the liberty to report, and even to certify in the public news-papers, that they have met with the highest applause and approbation. And therefore it is hoped, that no regard will hereafter be paid to such reports, and public notices; which in some instances have been too lightly credited, to the dishonour of the Society.

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Meteorological Journal kept at the Apartments of the Royal Society, by Order of the President and Council.

THE PRESIDENT and COUNCIL of the ROYAL SOCIETY adjudged, for the year 1792, the Medal on Sir GODFREY COPLEY's Donation, to Sir BENJAMIN THOMPSON, now Count of RUMFORD, for his various Papers on the Properties and Communication of Heat.

PHILOSOPHICAL TRANSACTIONS.

I. *An Account of two Rainbows, seen at the same Time, at* Alverstoke, Hants, July 9, 1792. *By the Rev. Mr.* Sturges. *Communicated by* William Heberden, *M. D. F. R. S.*

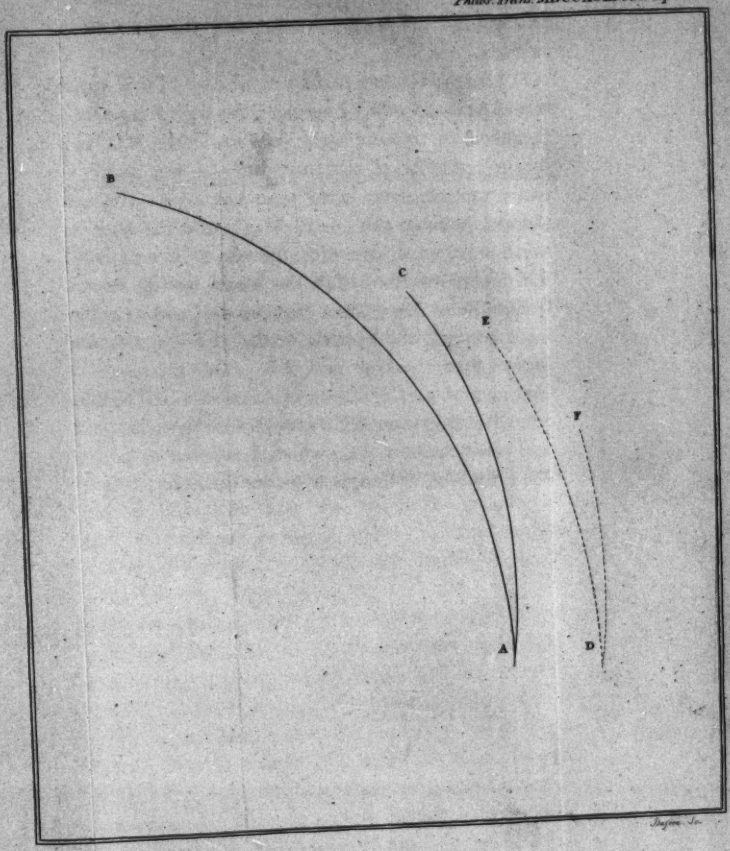
Read January 10, 1793.

On the evening of the 9th of July, 1792, between seven and eight o'clock, at Alverstoke, near Gosport, on the sea coast of Hampshire, there came up, in the south-east, a cloud with a thunder-shower; while the sun shone bright, low in the horizon to the north-west.

In this shower two primary rainbows appeared, AB and AC, (Tab. I.) not concentric, but touching each other at A, in the south part of the horizon; with a secondary bow to each, DE and DF (the last very faint, but discernible), which touched likewise, at D. Both the primary were very vivid for a considerable time, and at different times nearly equally so; but the bow AB was most permanent, was a larger segment of a circle, and at last, after the other had vanished, became almost a semicircle; the sun being near

setting. It was a perfect calm, and the sea was as smooth as glass.

If I might venture to offer a solution of this appearance, it would be as follows. I consider the bow AB as the true one, produced by the sun itself; and the other, AC, as produced by the reflection of the sun from the sea, which, in its perfectly smooth state, acted as a speculum. The direction of the sea, between the Isle of Wight and the land, was to the north-west, in a line with the sun, as it was then situated. The image reflected from the water, having its rays issuing from a point lower than the real sun, and in a line coming from beneath the horizon, would consequently form a bow higher than the true one, AB. And the shores, by which that narrow part of the sea is bounded, would, before the sun's actual setting, intercept its rays from the surface of the water, and cause the bow AC, which I suppose to be produced by the reflection, to disappear before the other.


B
C
E
F
A
D

II. *Description of the double horned Rhinoceros of* Sumatra. *By Mr.* William Bell, *Surgeon in the Service of the* East India *Company, at* Bencoolen. *Communicated by Sir* Joseph Banks, *Bart. P. R. S.*

Read January 10, 1793.

THE animal herein described was shot, with a leaden ball from a musket, about ten miles from Fort Marlborough. I saw it the day after; it was then not in the least putrid, and I put it into the position from which the accompanying drawing was made. (See Tab. II.)

It was a male, the height at the shoulder was four feet four inches; at the sacrum nearly the same; from the tip of the nose to the end of the tail, eight feet five inches. From the appearance of its teeth and bones it was but young, and probably not near its full size.

The shape of the animal was much like that of the hog. The general colour was a brownish ash; under the belly, between the legs and folds of the skin, a dirty flesh colour.

The head much resembled that of the single horned rhinoceros. The eyes were small, of a brown colour; the *membrana nictitans* thick and strong. The skin surrounding the eyes was wrinkled. The nostrils were wide. The upper lip was pointed, and hanging over the under.

There were six *molares*, or grinders, on each side of

the upper and lower jaw, becoming gradually larger backward, particularly in the upper. Two teeth in the front of each jaw.

The tongue was quite smooth.

The ears were small and pointed, lined and edged with short black hair, and situated like those of the single horned rhinoceros.

The horns were black, the larger was placed immediately above the nose, pointing upwards, and was bent a little back; it was about nine inches long. The small horn was four inches long, of a pyramidal shape, flattened a little, and placed above the eyes, rather a little more forward, standing in a line with the larger horn, immediately above it. They were both firmly attached to the skull, nor was there any appearance of joint, or muscles to move them.

The neck was thick and short, the skin on the under side thrown into folds, and these folds again wrinkled.

The body was bulky and round, and from the shoulder ran a line, or fold, as in the single horned rhinoceros, though it was but faintly marked. There were several other folds and wrinkles on the body and legs; and the whole gave rather the appearance of softness.

The legs were thick, short, and remarkably strong; the feet armed with three distinct hoofs, of a blackish colour, which surrounded half the foot, one in front, the others on each side. The soles of the feet were convex, of a light colour, and the cuticle on them not thicker than that on the foot of a man who is used to walking.

The testicles hardly appeared externally.

The penis was bent backward, and opened about eighteen

inches below the anus. At its origin it was as thick as a man's leg, and about two feet and a half long; the bend in it occasions the urine to be discharged backwards. The glans is very singular: the opening of the urethra is like the mouth of a cup with its brim bending over a little, and is about three quarters of an inch in diameter; the glans here is about half an inch in diameter, and continues that thickness for an inch and a half; it is then inserted into another cup like the first, but three times as large. The glans afterwards gradually becomes thicker, and at about nine inches from the opening of the urethra are placed two bodies on the upper part of the glans, very like the nipples of a milch cow, and as large; these become turgid when the penis is erected. The whole of this is contained in the prepuce, and may be considered as glans.

From the os pubis arises a strong muscle, which soon becomes tendinous. This tendon is continued along the back, or upper part, of the penis; it is flattened, is about the size of a man's little finger, and is inserted into the upper part of the glans, near the end. The use of this muscle is to straiten the penis.

On the under side of the penis there are two muscles, antagonists to the above; they arise from the os ischium fleshy, run along the lower side of the penis, on each side of the corpus spongiosum, and are inserted fleshy into the lower side of the glans. The action of these muscles will draw in the penis, and bend it.

The male has two nipples, like the female, situated between the hind legs, they are about half an inch in length, of a pyramidal form, rounded at the end.

The whole skin of the animal is rough, and covered very thinly with short black hair. The skin was not more than one third of an inch in thickness, at the strongest part; under the belly it was hardly a quarter of an inch; any part of it might be cut through with ease, by a common dissecting knife.

The animal had not that appearance of armour which is observed in the single horned rhinoceros.

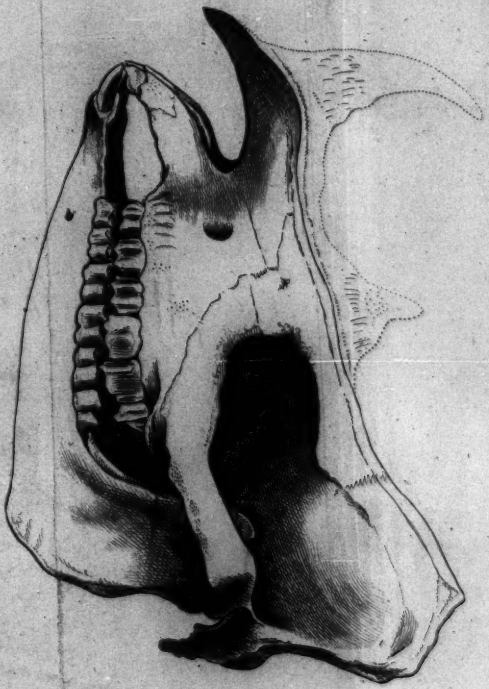
Since I dissected the male, I have had an opportunity of examining a female, which was more of a lead colour; it was younger than the male, and had not so many folds or wrinkles in its skin, of course it had still less the appearance of armour.

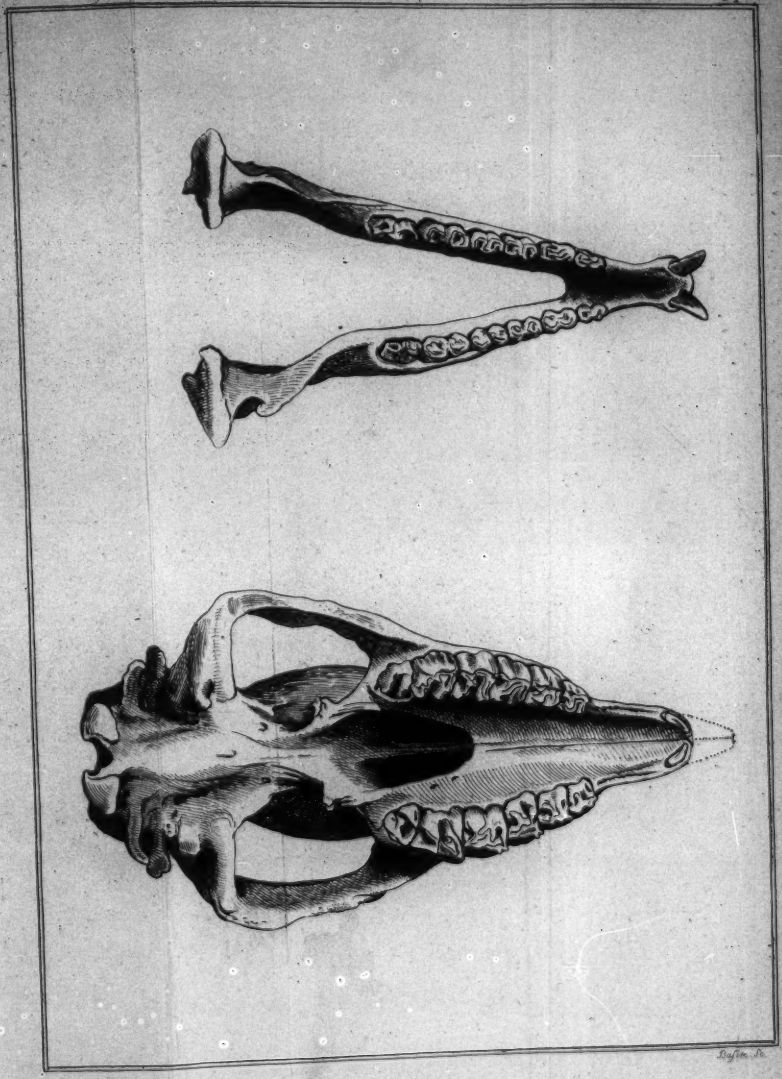
The only external mark which distinguishes it from the male is the vagina, which is close to the anus; whereas, in the male, the opening for the penis is eighteen inches below the anus.

Tab. II. Represents the entire animal.

Tab. III. The cranium.

Tab. IV. The upper and under jaw, separated from each other.





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III. *Description of a Species of Chætodon, called, by the* Malays, Ecan bonna. *By Mr.* William Bell, *Surgeon in the Service of the* East India *Company, at* Bencoolen. *Communicated by Sir* Joseph Banks, *Bart. P. R. S.*

Read January 17, 1793.

The fish called *Ecan bonna*, by the Malays, is broad, flat, and of a lead colour; the belly is flat, white, and in places tinged with green. The eyes are a bright yellow. The body is covered with small semicircular scales.

Its length is generally about eighteen inches; its breadth thirteen, and, at the thickest part, it is nearly three inches thick.

It is frequently caught at Bencoolen, and several other parts on the west coasts of Sumatra, and is said to grow to a much larger size. Its flesh is white, firm, and well flavoured, and it is considered as a good fish for the table.

It has six fins: two pectoral, two ventral, one dorsal, and one anal fin. The tail is broad, and of a triangular form.

The pectoral fins are small, blunted at their ends, and placed a little behind the gills.

The ventral fins are placed on the sternum, and are longer, and more pointed.

The dorsal fin arises at the beginning of the spinous processes of the back, and is continued down nearly to the tail.

The anal fin arises a little below the anus, and is also conti-

nued on almost to the tail. It is strong and broad, like the dorsal, and projects a little farther backward than it.

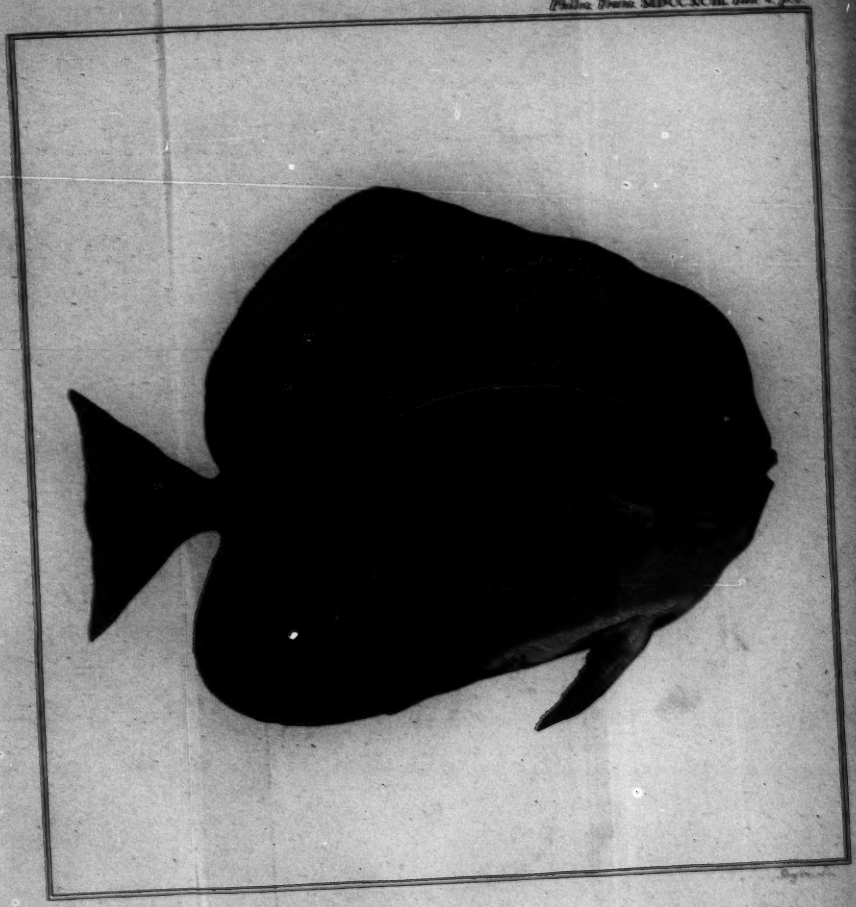
The mouth is small, and each jaw contains five rows of small teeth, about the thickness of hog's bristles, and of equal thickness throughout their length. The grinding, or cutting surfaces of the front, second, and third rows, in both jaws, are divided into three points. The two inner rows are pointed, and bent a little backward.

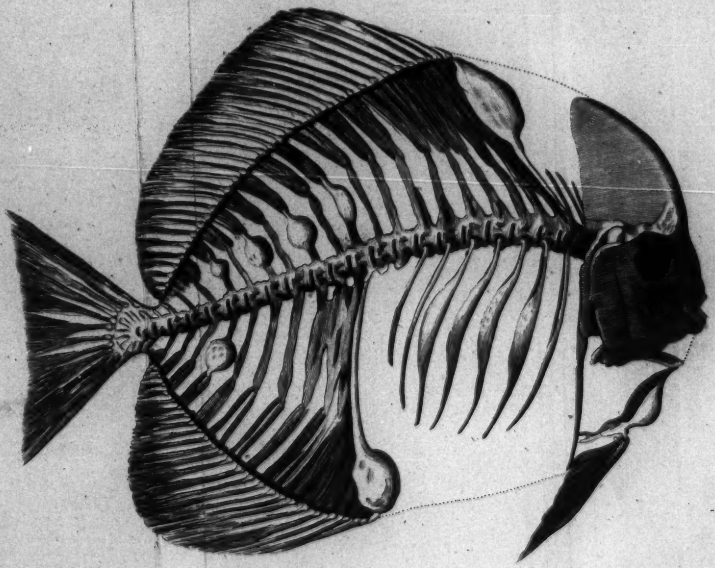
The stomach was empty, so that I had not an opportunity of ascertaining its food. The intestinal canal was long, like that of fish which feed on vegetables; and the œsophagus was thick set with pyramidal bodies, like the œsophagus of the turtle.

The skeleton is very singular, many of the bones having tumours, which, in the first fish I saw, I supposed to be exostoses arising from disease; but on dissecting a second, found the corresponding bones had exactly the same tumours, and the fishermen informed me they were always found in this fish; I therefore conclude them to be natural to it.

In Mr. HUNTER's collection are two or three of these bones, but I never knew what fish they belonged to; they were supposed to be from the back of some of the large rays.

What advantage can arise from these large tumours is difficult to say. Those on the spines of the vertebræ seem to answer no evident purpose, nor those at the origin of the dorsal, and anal fins. The particular form of the sternum, to which the ventral fins are joined, seems to be intended to give greater surface for the attachment of the muscles, and to increase their action.





These tumours are spongy, and so soft as to be easily cut with a knife; they were filled with oil.

The air-bladder is very large, for the size of the fish, probably to counteract the weight of the bony matter in the skeleton.

It is generally caught near the shore, where there are sea-weeds, and the Malays say it is a dull swimmer.

Tab. V. Represents the fish herein described.

Tab. VI. The skeleton of the same.

IV. *Account of some Discoveries made by Mr.* Galvani, *of* Bologna; *with Experiments and Observations on them. In two Letters from Mr.* Alexander Volta, *F. R. S. Professor of Natural Philosophy in the University of* Pavia, *to Mr.* Tiberius Cavallo, *F. R. S.*

Read January 31, 1793.

Le sujet des découvertes et des recherches, dont je vais vous entretenir, Monsieur, est *l'Electricité Animale*; sujet qui doit vous interesser vivement. Je ne sais si vous avez encore vu l'ouvrage d'un professeur de Bologna, Mr. Galvani, qui a paru il y a à-peu-près un an, avec ce titre; Aloysii Galvani *de Viribus Electricitatis in Motu Musculari Commentarius. Bononiæ*, 1791, *in 4to*, de 58 pages, avec quatre grandes planches; ou du moins si vous en avez eu notice. Il contient une des plus belles et des plus surprenantes découvertes, et le germe de plusieurs autres. Nos journaux Italiens en ont donné différents extraits, entre autres celui du Dr. Brugnatelli de Pavie, qui a pour titre, *Giornale Fisico-medico*; auquel j'ai fourni moi-même deux longs memoires, qui seront suivis de quelques autres, ayant beaucoup étendu les experiences, et poussé les recherches plus loin sur ce sujet.

Or c'est une esquisse, tant de la découverte admirable de Mr. Galvani, que des progrès que j'ai été assez heureux de faire dans cette nouvelle carrière, que je vais vous tracer, Monsieur, dans cet écrit, que je souhaite que vous presentiez

au digne President de la Societé Royale, le Chevalier BANKS, pour être communiqué, s'il le croit à propos, à cette savante Compagnie, comme un foible temoignage de ma reconnoissance pour l'honneur qu'elle m'a fait de m'associer à son corps, et de mon zele et empressement à répondre à son invitation de lui faire part, de tems à autre, du fruit de mes recherches.

(1.) Le Dr. GALVANI ayant coupé et préparé une grenouille, de maniere que les jambes tenoient à une partie de l'épine du dos, tronquée du reste du corps, uniquement par les nerfs cruraux mis à nud, vit qu'il s'excitoit des mouvements très vifs dans ces jambes, avec des contractions spasmodiques dans tous les muscles, chaque fois que (ce reste d'animal, se trouvant placé à une distance considerable du grand conducteur de la machine électrique, et dans certaines circonstances, que j'expliquerai ensuite,) on tiroit de ce même conducteur, non pas sur le corps de l'animal, mais sur tout autre corps, et dans toute autre direction, une étincelle. Les circonstances requises etoient donc, que l'animal, ainsi dissequé, se trouvât en contact, ou très près de quelque métal, ou autre bon conducteur assez étendu, et mieux encore entre deux semblables conducteurs, dont l'un étoit tourné vers l'extremité des dites jambes, ou quelqu'un de ses muscles, l'autre vers l'épine, ou les nerfs: il étoit aussi très avantageux, qu'un de ces conducteurs, que l'auteur distingue par le nom de *conducteur des nerfs*, et de *conducteur des muscles*, et préferablement ce dernier, eût une libre communication avec le plancher. C'est dans cette position surtout, que les jambes de la grenouille préparée, comme on a dit, recevoient de violentes secousses, s'élançoient et se debattoient avec vivacité à chaque étincelle du conducteur de la machine, quoiqu'il fût assez éloigné, et quoique la décharge

ne se fit, ni sur le conducteur des nerfs, ni sur celui des muscles, mais sur un autre quelconque, pareillement éloigné d'eux, et ayant tout autre communication par où transmettre une telle décharge, par exemple, sur une personne placée à l'angle opposé de la chambre.

(2.) Ce phénomene étonna Mr. GALVANI, peut-être plus qu'il n'auroit dû faire; car enfin le pouvoir, non seulement des étincelles électriques lorsqu'elles frappent immédiatement les muscles ou les nerfs d'un animal, mais d'un courant de ce fluide qui les traverse, de quelque manière que ce soit, avec une suffisante rapidité, son grand pouvoir, dis-je, d'y exciter des commotions, étoit une chose assez connue; d'ailleurs il étoit visible comment, dans cette expérience, et dans toutes celles du même genre rapportées dans la première et seconde partie de son ouvrage, et qui sont représentées dans les deux premieres planches de figures, sa grenouille se trouvoit effectivement exposée à être traversée par un tel courant. On n'a qu'à se retracer l'action très-connue des atmospheres électriques, ou ce qu'on appelle *electricité de pression*; par laquelle le fluide des corps *déférents*, plongés dans la sphere d'activité d'un corps électrisé quelconque, est poussé et deplacé, en raison de la force, et de l'étendu, de cette sphere, et entretenu en cet état de déplacement tant que l'électricité dans le corps dominant subsiste, laquelle otée il revient à sa place des endroits éloignés, peu-à-peu si elle se dissipe petit à petit, et en un instant si on la détruit instantanément, en déchargeant tout d'un coup le corps qui en est revêtu. C'est donc ce *courant de retour*, ce reflux de fluide électrique dans les corps *déférents* contigus à la grenouille, ou proches d'elle, son passage brusque du *conducteur des muscles* au *conducteur des*

nerfs, ou *vice versa*, à travers son corps, surtout lorsqu'un tel courant est resserré dans le canal unique et etroit des nerfs, qui excite les spasmes et les mouvements dans les expériences dont il est ici question. Mr. GALVANI, qui semble n'avoir pas assez réfléchi à cette action des atmospheres électriques, et qui ne connoissoit pas encore la prodigieuse sensibilité de sa grenouille, singulierement préparée de la maniere susdite, (je dirai ici, que je l'ai trouvée à-peu-près égale dans tous les autres petits animaux, comme lezards, salamandres, souris) fut extremement frappé d'un tel effet, qui ne paroitra pas si merveilleux à d'autres physiciens. Ce fut pourtant le premier pas, qui le conduisit à la belle et grande découverte d'une *électricité animale* proprement dite, appartenante non seulement aux grenouilles, et à d'autres animaux à sang froid, mais aussi-bien à tous les animaux à sang chaud, quadrupedes, oiseaux, &c.; découverte qui fait le sujet de la troisieme partie de son ouvrage, sujet absolument neuf, et très interessant. C'est ainsi qu'il nous a ouvert un champ très vaste, dans lequel nous nous proposons d'entrer, et de poursuivre les recherches, après que nous nous serons arreté encore un peu sur ces experiences préliminaires qui concernent l'action de l'électricité artificielle, ou étrangere, sur les fibres nerveuses et musculaires.

(3.) Ce fut le hazard qui presenta à Mr. GALVANI le phénomene que nous venons de décrire, et dont il fut étonné, je le répéte, plus qu'il n'auroit dû être. Cependant qui est ce qui auroit cru, qu'un courant électrique, foible au point de ne pouvoir être rendu sensible par les électrometres les plus delicats, fût capable d'affecter si puissamment les organes d'un animal, et d'exciter dans ses membres, découpés une ou plusieurs heures

avant, des mouvements, tels que l'animal vivant n'en produit pas de plus forts, comme d'élancer vigoureusement les jambes, de sauter, &c. pour ne rien dire des convulsions toniques les plus violentes? Or tel est le courant qui envahit le petit animal couché, par exemple, sur la table, auprès de quelque métal, ou entre deux bons conducteurs non isolés, lorsqu'une personne tire du grand conducteur électrique, suspendu plusieurs pieds au dessus, une médiocre étincelle, et dirige la décharge par une tout autre voie.

(4.) Je dis *médiocre*; car si elle est bien forte, et si la distance de ce conducteur, puissamment électrisé et volumineux, aux corps posés sur la table n'est pas fort grande, il paroîtra des petites étincelles dans les interstices de ces corps surtout métalliques, et là même ou la grenouille fait un anneau de communication entr'eux; étincelles produites evidemment par ce fluide électrique de retour, dont nous avons parlé ci-dessus. (sect. 2.) Ou, si la chose n'arrive pas à ce point, au lieu des étincelles, on pourra observer des mouvements assez marqués de quelques électrometres placés sur la même table, et aux mêmes endroits. Or dans ce cas, où les électrometres donnent des signes, et beaucoup plus dans l'autre, où l'on obtient les susdites étincelles, on pourra observer que même une grenouille entiere et intacte, où un autre petit animal quelconque, un lezard, un souris, un moineau, sont saisis de fortes convulsions dans tous leurs membres, surtout dans les jambes, qui s'élancent avec vivacité, si le passage du fluide électrique (le courant de retour) suit la direction de ces mêmes jambes d'un bout à l'autre. Jusques-là point de merveille; la surprise est dans le cas où le courant électrique n'étant plus sensible, pas même aux électrometres les plus delicats, il excite

encore les mêmes convulsions, les mêmes mouvements et debats, si non dans la grenouille entiere, au moins dans ses membres disséqués et préparés à la manière de Mr. GALVANI.

(5.) Je me suis appliqué, avec quelque attention, à determiner quelle étoit la moindre force électrique requise à produire ces effets, aussi bien dans une grenouille intacte et pleine de vie, que dans une disséquée et préparée à la dite maniere; ce que Mr. GALVANI avoit omis de faire. J'ai choisi la grenouille de préference à tout autre animal, à cause qu'elle est douée d'une vitalité très-durable, et qu'il est fort aisé de la préparer. Au reste j'ai aussi fait des épreuves sur d'autres petits animaux, dans cette vue, et avec un succès à-peu-près égal. Pour bien évaluer la force du courant électrique, j'ai cru devoir soumettre l'animal destiné aux expériences de ce genre, non pas aux courants de retour occasionnés par les atmospheres, (sect. 2.) mais aux décharges électriques directes, tantôt d'un simple conducteur, tantôt d'une bouteille de Leyde, et en sorte que tout le courant dût traverser le corps de l'animal. A cet effet j'avois soin de le tenir isolé d'une maniere ou de l'autre, et le plus souvent en l'attachant, par des epingles, à deux plateaux de bois tendre, portés par des colonnes de verre.

(6.) J'ai donc trouvé, que pour la grenouille vivante et entiere il suffisoit de l'électricité d'un simple conducteur, de moyenne grandeur, quand elle arrivoit seulement à pouvoir donner une très foible étincelle, et à élever de cinq à six degrés l'électrometre de HENLY. Que si je me servois d'une bouteille de Leyde, aussi de moyenne grandeur, une charge de celle-ci beaucoup plus foible produisoit l'effet, telle, par exemple, que ne donnant pas la moindre étincelle, et n'étant aucunement

sensible au quadrant-électrometre, l'étoit à peine à un électrometre de CAVALLO au point d'écarter d'une ligne environ ses petits pendules.

(7.) Cela, comme je viens de montrer, pour une grenouille entiere et intacte; car pour une disséquée et préparée en différentes manières, et sur-tout à la façon de GALVANI, où les jambes tiennent à l'épine dorsale par les seuls nerfs cruraux, une électricité beaucoup plus foible encore, soit du conducteur, soit de la bouteille de Leyde, (le fluide étant obligé d'enfiler ce passage étroit des nerfs,) ne manquoit pas d'exciter les convulsions, &c. Oui une électricité quarante ou cinquante fois plus foible, comme une charge de la bouteille absolument imperceptible au dit électrometre de CAVALLO, et même à celui extremement delicat de BENNET; une charge, que je ne pouvois rendre sensible qu'à l'aide de mon *condensateur*, et que je crois pouvoir évaluer à cinq ou six centiemes de degré de l'électrometre de CAVALLO.

(8.) Voila donc, dans les jambes de la grenouille attachées à l'épine du dos uniquement par ses nerfs bien dépouillés, une nouvelle espèce d'électrometre; puisque des charges électriques qui, ne donnant aucun signe à ceux-ci, paroitroient nulles, en donnent de si marqués par ce nouveau moyen, par un tel *électrometre animal*, si on peut l'appeller ainsi.

(9.) Lorsqu'on a vu comment une grenouille ainsi préparée se ressent, et est saisie de fortes convulsions par une électricité extremement foible, par un courant de fluide imperceptible, on ne doit surement plus être surpris, qu'elle se debatte de même lorsqu'un corps quelconque décharge tout d'un coup le grand conducteur de la machine électrique; et fait qu'un autre courant de fluide électrique, grand ou petit, du

fluide ci-devant déplacé dans les corps *déférents* auprès de la grenouille, et qui se rétablit, comme on a expliqué plus haut, (sect. 2) passe rapidement à travers ses nerfs. Supposons que ce courant de retour soit à peine équivalent à celui que lance directement un conducteur suffisamment volumineux, avec une électricité non étincellante, et presqu' insensible jusqu'à l'électrometre de CAVALLO, ou une petite bouteille de Leyde, chargée à peine un dixieme de degré de ce même électrometre ; supposons, dis-je, que le courant électrique ne soit pas plus fort que cela, il suffit encore, comme mes expériences, rapportées ci-dessus, (sect. 6. et 7.) font voir, pour exciter les mouvements dont il s'agit.

(10.) Mais si on ne doit plus être surpris, après ces expériences, de celles de Mr. GALVANI décrites dans la première et seconde partie de son ouvrage, comment s'empecher de l'être de celles tout-à-fait nouvelles et merveilleuses qu'il rapporte dans la troisième ? Par lesquelles il obtint les mêmes convulsions et mouvements violents des membres, sans avoir recours à aucune électricité artificielle, ou excitation étrangere, par la seule application d'un *arc conducteur* quelconque, dont un bout touchât aux muscles, et l'autre aux nerfs ou à l'epine de la grenouille, preparée de la manière decrite. Cet arc conducteur pouvoit être ou entièrement métallique, ou partie métallique partie d'autres corps de la classe des *déférents*, comme d'eau, d'une ou plusieurs personnes, &c. Même les bois, les murailles, le plancher, pouvoient entrer dans le circuit, pourvu qu'ils ne fussent pas trop secs ; il n'y avoit que l'interposition des corps *cohibents*, comme verre, resines, soye, qui empechât l'effet. Les mauvais conducteurs cependant ne servoient pas si bien, et seulement pour les premiers moments après la

préparation de la grenouille, tant que les forces vitales se soutenoient en pleine vigueur; après quoi il n'y avoit plus que les bons conducteurs qu'on pût employer avec succès, et bientôt on ne pouvoit réussir qu'avec les excellents, c'est à dire, avec des arcs conducteurs entièrement métalliques. Il trouva au surplus un grand avantage à appliquer une espèce d'armure métallique à cette portion d'épine qu'il laissoit attachée aux nerfs cruraux, et aux nerfs eux-mêmes, et surtout à revêtir cette partie d'une feuille mince d'étain ou de plomb.

(11.) Mr. GALVANI ne s'arreta pas, dans ces expériences vraiment étonnantes, aux grenouilles; il les étendit avec succès, non seulement à plusieurs autres animaux à sang-froid, mais aussi aux quadrupedes, et aux oiseaux; dans lesquels il obtint les mêmes resultats, moyennant les mêmes préparations; qui consistoient à degager de ses enveloppes un des principaux nerfs, là où il s'implante dans un membre susceptible de mouvement, à armer ce nerf de quelque lame ou feuille métallique, et à etablir une communication, à l'aide d'un arc conducteur, de cette armure du nerf aux muscles dépendants.

(12.) C'est ainsi qu'il découvrit heureusement, et nous demontra, de la manière la plus evidente, l'existence d'une veritable *électricité animale* dans tous, ou presque tous les animaux. Il paroit prouvé en effet par ses expériences, que le fluide électrique tend sans cesse à passer d'une partie à l'autre du corp organique vivant, et même des membres tronqués, tant qu'il y subsiste un reste de vitalité; qu'il tend à passer des nerfs aux muscles, ou *vice versa*, et que les mouvements musculaires sont dûs à une semblable transfusion, plus ou moins rapide. En verité il semble qu'on ne peut rien opposer à cela, ni à la façon dont Mr. GALVANI explique la chose, par

une espèce de décharge semblable à celle de la bouteille de Leyde. Cependant un grand nombre de nouvelles expériences, que j'ai faites sur ce sujet, font voir qu'il y a bien des restrictions à faire, tant à la chose, qu'aux consequences que l'auteur en a tirées; en même tems qu'elles étendent beaucoup les phénomenes attribués à cette *électricité animale*, et nous la representent dans un grand nombre de circonstances et de combinaisons nouvelles.

(13.) Mr. GALVANI, suivant l'idée qu'il s'est fait, d'après ses expériences, et pour suivre, en tout point, l'analogie de la bouteille de Leyde et de l'arc conducteur, prétend qu'il y ait naturellement un excès de fluide électrique dans le nerf, ou dans l'interieur du muscle, et un defaut correspondant dans l'exterieur, ou *vice versa*; et suppose conséquemment qu'un bout de cet arc doit communiquer au nerf, qu'il regarde comme le fil conducteur, ou crochet de la bouteille; l'autre bout à la face exterieure du muscle. Toutes les figures de la troisième et quatrième planche, et toutes ses explications reviennent à cela. Mais s'il avoit un peu plus varié les expériences, comme j'ai fait, il auroit vu que ce double contact du nerf et du muscle, ce circuit qu'il imagine, n'est pas toujours nécessaire. Il auroit trouvé, ce que j'ai trouvé, qu'on peut exciter les mêmes convulsions, les mêmes mouvements, dans les jambes, et autres membres des grenouilles, et de tout autre animal, par des attouchements métalliques, soit à deux parties du nerf seul, soit à deux muscles, et même à differents points d'un seul et simple muscle.

(14.) Il est vrai qu'on ne reussit pas, à beaucoup près, si bien de cette manière que de l'autre, et qu'il faut, dans ce cas, avoir recours à un artifice, dont nous aurons occasion de parler

plus au long, et qui consiste à employer deux métaux differents ; artifice qui n'est pas absolument necessaire lorsqu'on expérimente suivant le procédé de GALVANI, decrit ci-dessus, (sect. 10. et 11.) du moins tant que la vitalité dans l'animal, ou dans ses membres coupés, se soutient en pleine vigueur ; mais enfin, puisque avec des armures de differents métaux appliquées, soit aux nerfs seuls, soit aux seuls muscles, on vient à bout d'exciter les contractions dans ceux-ci, et les mouvements des membres, on doit conclure que s'il y a des cas (ce qui pourroit bien encore paroitre douteux) où la pretendue décharge entre nerf et muscle (sect. 12. et 13.) est cause des mouvements musculaires, il y a bien aussi des circonstances, et plus fréquentes, où l'on obtient les mêmes mouvements, par un tout autre jeu, par une tout autre circulation, du fluide électrique.

(15.) Oui c'est un tout autre jeu du fluide électrique, dont on doit dire plutôt qu'on trouble l'equilibre, que de le retablir, en ce qu'il coule d'une partie à l'autre du nerf, du muscle, &c. tant interieurement par leurs fibres conductrices, qu'extérieurement par la voie des conducteurs métalliques appliquées, non pas en conséquence d'un excès ou defaut respectif, mais par une action propre de ces mêmes métaux, lorsque ceux-ci sont de differente espece. C'est ainsi que j'ai découvert une nouvelle loi, qui n'est pas tant une loi d'électricité animale, qu'une loi d'électricité commune ; à laquelle on doit attribuer la plûpart des phénomenes, qui paroissoient, d'après les expériences de GALVANI, et d'après plusieurs autres que j'avois faites moi-même à la suite de celles-là, appartenir à une veritable électricité animale spontanée, et qui n'en sont pas ; ce sont réellement des effets d'une électricité artificielle très foible, qui

s'excite d'une manière dont on ne s'étoit pas douté, par la simple application de deux armures de differents métaux, comme j'ai deja indiqué, et que j'expliquerai mieux ailleurs.

(16.) Je dois dire ici, qu'à la découverte de cette loi nouvelle, de cette électricité artificielle jusqu'à présent inconnue, je me defiai d'abord de tout ce qui m'avoit paru demontrer une électricité animale naturelle, dans le sens propre, et que j'etois sur le point de revenir de cette idée. Mais repassant, avec un examen reflechi, tous les phénomenes, et repetant les expériences sous ce nouveau point de vue, je trouvai enfin que quelques unes soutiennent encore cet examen, (celles, par exemple, où l'on n'a pas besoin d'armures differentes, ni même d'armure quelconque, un simple fil métallique, ou tout autre corps déférent, faisant office d'arc conducteur entre le nerf isolé et un des muscles dépendants, pouvant exciter dans ceux-ci les convulsions), (sect. 10, &c.) et qu'ainsi l'électricité animale naturelle et proprement organique subsiste, et ne peut pas être renversée entièrement. Les phénomenes qui l'établissent, quoique beaucoup plus limités, ne laissent pas que d'être demonstratifs, comme je viens d'indiquer, et comme on verra mieux dans la suite.

(17.) Ce qu'on trouvera peut-être plus desagréable, c'est qu'il faut aussi renfermer en des limites plus étroits son empire dans l'économie animale, et renoncer aux plus belles idées qu'on avoit conçues, et qui paroissoient nous mener à expliquer clairement tous les mouvements des muscles. Mes expériences, variées de toutes les manières possibles, montrent que le mouvement du fluide électrique, excité dans les organes, n'agit point immédiatement sur les muscles; qu'il ne fait qu'exciter les nerfs, et que ceux-ci, mis en action, excitent

à leur tour les muscles. Quelle soit cette action des nerfs; comment elle se propage d'une de ses parties aux autres; comment elle passe aux muscles, et comment il en resulte le mouvement de ces derniers; ce sont encore des problemes, pour l'explication desquels nous n'en sommes pas plus avancés qu'avant la découverte dont il s'agit.

(18.) Je viens maintenant aux expériences qui prouvent toutes les assertions que j'ai avancées dans ces derniers paragraphes. Dans la foule qui se présente j'en choisirai quelques unes seulement, celles qui me paroissent mieux établir certains principes, la plûpart nouveaux et differents de ceux adoptés par Mr. GALVANI. Mais disons premièrement encore un mot des expériences de cet auteur. Je ne sais s'il en a fait d'autres, mais celles dont il nous rend compte dans son ouvrage sont renfermées dans un cercle trop étroit; il s'agit toújours de découvrir et isoler les nerfs, et d'établir une communication, de corps conducteurs de l'électricité, entre ces nerfs et les muscles qui en dépendent, (comme on voit dans toutes les figures des quatres planches jointes à ce même ouvrage) lorsqu'on se propose d'exciter les convulsions et mouvements de ces muscles, par l'action du fluide électrique. Il suppose donc, dans tous les cas, et il s'explique la dessus assez clairement, que la transfusion du fluide électrique produite, soit par l'électricité artificielle, soit par l'électricité animale naturelle, doive se faire des nerfs aux muscles, ou *vice versa*; que ces deux termes au moins y doivent être compris, pour que les mouvements musculaires ayent lieu; et vraiment toutes les expériences qu'il nous décrit semblent prouver cela. Mais c'est qu'elles roulent, comme j'ai déja dit, dans ce cercle trop étroit, dont il n'est jamais, ou presque jamais, sorti. En variant les

expériences de ce genre de plusieurs manières, j'ai fait voir, que ni l'une ni l'autre de ces conditions, savoir, de découvrir et isoler les nerfs, et de toucher simultanément ceux-ci et les muscles, pour procurer la prétendue décharge, sont absolument necéssaires (sect 13.). Il suffit, lorsqu'on a par exemple découvert le nerf ischiatique à un chien, à un agneau, &c. de faire passer un courant électrique d'une partie de ce nerf à une autre, même prochaine, en laissant tout le reste intact et libre, et intacte encore plus toute la jambe ; il suffit, dis-je, de cela pour voir excités dans cette jambe les convulsions et les mouvements les plus forts ; et cela, soit qu'on employe une électricité artificiélle étrangere, soit qu'on mette en mouvement le fluide électrique inhérent au nerf lui-même. Voici de quelle manière je fais ces expériences.

(19.) EXPERIENCE A. Je serre, avec des pincettes, le nerf ischiatique un peu au dessus de son insertion dans la cuisse, et j'applique, quelques lignes plus haut, une piece de monnoye, ou une autre lame métallique, sur ce même nerf, detaché soigneusement de ses adhérences, et soutenu par un fil, ou appuyé à une plaque de verre, à un bâton de cire d'Espagne, ou de bois sec, ou à tout autre corps mauvais conducteur. Alors appuyant le ventre d'une bouteille de Leyde, très foiblement chargée, aux dites pincettes, je porte le crochet en contact de l'autre lame métallique ; et voila que la décharge qui se fait, quand même elle n'est pas assez forte pour donner la moindre étincelle, fait entrer en convulsion tous les muscles de la cuisse et de la jambe, qui est secouée et s'élance avec plus ou moins d'impetuosité. Et cependant toute cette jambe, et une partie même du nerf qui en deborde, se trouvoient, comme on voit, hors la route que le fluide électrique a parcouru dans son

trajet, de sorte qu'une petite partie seulement du nerf a pu être irritée; cela néanmoins a suffi pour occasionner la contraction des muscles.

(20.) EXPERIENCE B. Il en est de même, c'est-à-dire de semblables convulsions et mouvements de la jambe ont lieu, sans avoir recours à une électricité étrangere, par la décharge qui se fait, en certaine manière naturellement, lorsqu'ayant appliqué, comme ci-dessus, les mêmes pincettes, ou une lame d'argent, à une partie du nerf, et une lame de tout autre métal, et surtout d'étain ou de plomb, à une autre partie, on les fait simplement communiquer entr'elles, soit par un contact immédiat, ou par l'entremise d'une troisième piece de métal, qui fasse l'office d'arc conducteur.

(21.) Or donc voila les mêmes effets, des convulsions et mouvements musculaires les plus vifs, sans que la décharge de fluide électrique se fasse entre les nerfs et les muscles, comme Mr. GALVANI suppose toujours; et sans qu'il soit besoin qu'un bout de l'arc conducteur communique aux uns, et l'autre bout aux autres. Mais aussi l'autre condition, de dépouiller un nerf quelconque et le mettre à nud, n'est pas plus requise, comme les expériences suivantes vont montrer.

EXPERIENCE C. J'applique les armures, ou lames de différents métaux (c'est cette difference des armures qui est essentielle) (sect. 14. et 15.) à une grenouille toute entière et vivante, revetue même de sa peau, en un mot intacte: je colle, par exemple, une feuille mince d'étain sur son dos, ou sur les reins, et je pose une piece de monnoye d'argent sous ses cuisses, ou sous son ventre, l'y comprimant un peu; cela fait, j'avance cette monnoye, en la glissant, jusqu'au contact de la feuille d'étain, ou bien j'établis une communication entre ces

deux armures, moyennant un fil d'archal, ou une autre piece de métal quelconque ; et voila qu'il s'excite des convulsions spasmodiques dans tous les muscles du ventre, des cuisses, du dos, avec de violentes secousses des jambes, une contraction et courbure de l'épine, &c. lesquelles convulsions et spasmes, quoique presqu'universelles, sont cependant plus marqués dans les membres et muscles qui touchent, ou avoisinent, les armures, et plus encore dans ceux qui dépendent des principaux nerfs proches eux-mêmes aux dites armures.

(22.) Ces expériences reussissent dans quelques autres animaux ; dans les poissons, et dans les anguilles sur-tout, auxquels il n'est pas nécessaire d'ôter la peau, quoiqu'elle ne laisse pas que d'empêcher un peu l'action. C'est pourquoi en la leur otant, au moins en partie, particulièrement à la grenouille, on obtient plus surement les effets, et on les obtient beaucoup plus grands. On gagne encore, à cet égard, si on coupe la tête à la grenouille, et si on finit de la tuer en lui enfonçant une grosse épingle dans la moëlle épiniere ; on excite alors, par le moyen décrit des armures métalliques différentes, des mouvements plus forts, ou qui paroissent au moins plus marqués, parce qu'ils ne se confondent pas avec les autres mouvements que l'animal se donne étant en vie.

(23.) S'il est avantageux, comme on vient de voir, d'ôter la peau aux grenouilles, quoique fort mince et assez humide, il l'est beaucoup plus, et même nécessaire, de l'ôter à presque tous les autres animaux, lezards, salamandres, serpents, tortues, et sur-tout aux quadrupedes, et aux oiseaux, fournis d'une peau plus seche, et beaucoup plus épaisse, pour reussir dans ces expériences. Voici donc comment je m'y prends.

EXPERIENCE D. J'attache à une table, au moyen de

quelques grosses épingles, un lezard, une souris, un poulet, &c. et en faisant une incision à la peau et aux autres intéguments, jusqu'à la chair nue, sur le dos de l'animal ainsi assujetti, je renverse les intéguments des deux cotés; j'en fais autant à la cuisse ou à la jambe, après quoi j'applique les deux armures aux endroits dénués, ici la feuille d'étain, là la cuiller ou la piece de monnoye. Alors, toutes les fois que je fais communiquer entr'elles ces deux armures, il s'excite de fortes contractions dans les muscles adjacents, et sur-tout dans ceux de la cuisse et de la jambe, qui remue et se debat très-fort. Ces secousses sont beaucoup plus violentes selon que la feuille d'étain se trouve appliquée plus près du nerf ischiatique, et la lame d'argent mieux appliquée au muscle qu'on appelle *gluteus*, ou à l'autre dit *gastrocnemius*, et toujours plus si on va jusqu'à découvrir ce même nerf, et a le revêtir lui-même de la feuille d'étain; si, le laissant attaché seulement aux muscles dans lesquels il s'implante, on lui ôte tout autre adherence; si enfin on détache tout le membre du reste du corps, avec son nerf pendant, et on l'assujettit seul aux expériences.

Je suis, &c.

A. VOLTA.

Septembre 13, 1792.

Second Letter.

(24.) AU reste on comprend bien que ce que je viens de faire observer, par rapport aù nerf ischiatique et à la jambe, a lieu pour le nerf brachial et le bras, et pour tout autre nerf relativement aux muscles et membres régis par ces nerfs.

(25.) Ces dernières préparations reviennent à celles de Mr. GALVANI; et elles prouvent bien qu'il est avantageux de mettre à découvert les nerfs, et plus encore de les détacher tout-au-tour; mais nullement que ce soit une condition nécessaire, puisqu'on ne manque pas d'obtenir les mêmes convulsions et mouvements des membres lorsqu'on découvre simplement les muscles, et qu'on laisse tous les nerfs enveloppés et cachés sous eux dans l'état naturel, comme toutes mes autres expériences ci-devant rapportées (sect. 21. 22. 23.) font voir.

(26.) Après ces essais sur des reptiles, sur des oiseaux, et sur de petits quadrupedes, je procedai à d'autres animaux plus grands, lapins, chiens, agneaux, bœufs; et non seulement je parvins à produire de semblables effets par toutes les manières décrites, mais à en obtenir de plus marqués et plus durables, à raison que la chaleur vitale se soutenoit dans ces grands animaux, et dans leurs membres, plus long-tems. Car je ne dois pas négliger de dire, que si dans la plûpart des animaux à sang froid, et particulièrement dans les grenouilles, la vitalité subsiste dans les membres tronqués plusieurs heures, cette vitalité qui les rend si sensibles à la plus foible irritation électrique, elle ne dure gueres que quelques minutes

dans les membres découpés des animaux à sang chaud, et disparoit communément avant que toute cette chaleur animale soit dissipée.

(27.) Ayant eu un tel succès de mes expériences sur des animaux grands et petits de toute espèce, tantôt vivants et dans toute leur intégrité, tantôt écorchés, quelquefois decapités, et dissequés de différentes manières, et dans chacun de leurs gros membres tronqués, et presque toujours sans cette préparation requise par Mr. GALVANI, c'est à dire, sans mettre à decouvert les nerfs, je voulus aller plus loin, et essayer sur de petits membres, sur un seul muscle, et sur de petits morceaux de muscles; et le nouveau succès que j'en ai eu m'a conduit à d'autres découvertes, que j'exposerai bientôt, après avoir décrit quelques unes de ces expériences.

(28.) EXPERIENCE E. J'ai coupé tantôt une jambe avec la cuisse, tantôt la jambe seule, tantôt une moitié ou un quart de jambe, à une grenouille; et ayant appliqué, à l'ordinaire, à une partie de la piece coupée la feuille d'étain, et à une autre partie la lame d'argent, et fait communiquer entr'elles ces armures, j'obtins toujours des convulsions et mouvements. J'en ai détaché un seul muscle, par exemple le *gluteus* ou le *gastrocnemius*; d'autres fois je n'en ai pris qu'un morceau pas plus gros qu'un grain d'orge; mêmes effets, savoir, des contractions très vives et spasmodiques de ces muscles, ou de ces morceaux de muscles, moyennant l'artifice de deux armures differentes, &c.

EXPERIENCE F. J'ai répété les mêmes expériences sur une jambe, une moitié et un tiers de jambe, sur un seul muscle, et un fragment de muscle, de poulet, et d'autres oiseaux; sur une

tranche du *gluteus* d'un lapin, d'un agneau, &c. et j'ai eu les mêmes effets tout le tems que les chairs ont conservé une chaleur sensible. (sect. 26.)

(29.) Ainsi donc on excite des contractions très fortes dans les muscles des animaux à sang chaud, comme à sang froid, et dans toutes les parties coupées des muscles; et on les excite par le simple artifice des armures métalliques différentes, appliquées au muscle lui-même, sans aucune préparation des nerfs, même sans decouvrir ceux-ci. Ailleurs nous avons vu qu'on les excite également, et par le même moyen des armures appliquées à deux parties voisines du nerf seul, (sect. 19. et 20. Expérience A. et B.) d'où j'ai raison de conclure qu'il n'est pas du tout necessaire qu'il se fasse une décharge de fluide électrique entre nerf et muscle, ou qu'il s'en transporte de l'interieur à l'exterieur de ce dernier par le nerf et par l'arc conducteur, comme Mr. GALVANI suppose, ou *vice versa*; et qu'il n'y à aucune comparaison à faire du muscle avec la bouteille de Leyde et sa décharge, dans les expériences dont il s'agit ici. Qu'y a-t-il en effet qui resemble, et qu'on puisse expliquer analogiquement à la bouteille, lorsque les deux lames de métal, auxquelles arrivent les deux bouts de l'arc conducteur, se trouvent appliquées très près l'une de l'autre à l'extérieur du même nerf, (Expérience A. et B.) ou sur l'extérieur de deux muscles semblables, ou sur le même muscle; (Expérience C. D. E. F.) il faut convenir qu'on feroit inutilement des efforts pour soutenir ici une analogie avec la bouteille de Leyde.

(30.) EXPERIENCE G. Ayant revêtu de deux feuilles, une d'argent l'autre d'étain, les deux cuisses d'une grenouille aux endroits precisément correspondants, on excite les contractions

des muscles, et les mouvements ordinaires des jambes, au moment qu'on fait communiquer par un arc conducteur ces deux armures.

(31.) Est ce comme cela, je demande, que se fait la décharge de deux bouteilles de Leyde, en établissant une communication entre les surfaces homologues? Laissons donc là ces idées de bouteille et décharge, et toute explication forcée, et disons simplement qu'il se fait ici, et dans les expériences analogues, un transport de fluide électrique de l'une à l'autre des deux parties convenablement armées; transport déterminé, non par un *excès respectif* de ce fluide, qu'on ne sauroit naturellement supposer entre des parties similaires, mais par la diversité de ces mêmes armures, qui doivent être de différents métaux, comme j'ai eu soin d'indiquer deja, (sect. 20. et 21. Expérience B. et C.) et toujours inculqué dans la suite. En effet,

(32.) EXPERIENCE H. Si deux muscles, ou deux endroits d'un seul muscle, sont armés pareillement, c'est à dire, de deux lames d'un même métal, égales aussi quant à leur trempe et dureté, souplesse ou rigidité, quant au poli ou à la rudesse des superficies, et appliquées de la même manière, on aura beau les faire communiquer par un arc conducteur, il ne s'ensuivra aucune convulsion, aucun mouvement.

(33.) J'avoue qu'il n'est pas aisé de concevoir comment et pourquoi la simple application de deux armures dissemblables, je veux dire de deux différents métaux, à deux parties similaires de l'animal, et même à des points très proches les uns des autres d'un muscle quelconque, trouble l'équilibre du fluide électrique, et, le tirant de son repos et de son inaction, le sollicite de passer incessamment d'un endroit à l'autre; lequel

transflux a lieu sitôt qu'on établit un arc conducteur entre ces deux armures dissemblables, et continue tout le tems que cette communication subsiste. Mais concevable ou non, qu'en soit la cause, c'est un fait que les expériences deja rapportées prouvent assez, et qui sera confirmé par beaucoup d'autres; à la suite desquelles je tâcherai d'en donner quelqu'explication. C'est un fait qu'on doit ajouter à ce que nous connoissions deja en électricité; un fait qui doit surement paroître extraordinaire, et difficile à concilier avec les lois communément établies. C'est véritablement une nouvelle loi bien singuliere, que j'ai découverte; une loi qui n'appartient pas proprement à l'électricité animale, mais à l'électricité commune, puisque ce transflux de fluide électrique, transflux qui n'est pas au surplus momentané, comme seroit une décharge, mais continu et suivi tout le tems que la communication entre les deux armures subsiste, a lieu, soit que celles-ci se trouvent appliquées aux substances animales vivantes ou mortes, ou à d'autres conducteurs non métalliques, mais suffisamment bons, comme à l'eau, ou à des corps mouillés. Mais avant que d'en venir aux expériences qui prouvent décidément tout ce que j'avance ici, je dois encore m'arrêter quelque peu sur celles que j'ai deja rapportées. (sect. 20.—32.)

(34.) Il paroit d'abord par celles-ci qu'on peut exciter, moyennant le simple artifice des armures de différents métaux convenablement appliquées, de fortes contractions dans tous les muscles de tous les animaux, tant qu'ils jouissent encore de quelque vitalité. Une telle conclusion seroit pourtant trop génerale, et l'expérience même, au milieu des preuves que j'ai si fort étendues, m'a appris qu'il faut y mettre des restrictions, tant relativement aux classes et

genres d'animaux, que par rapport aux différents muscles de chaque animal.

(35.) Et premièrement pour ce qui est des différentes classes d'animaux; quoiqu'il soit bien constant que tous les quadrupedes, les oiseaux, les poissons, les reptiles, et les amphibies, que j'ai soumis aux épreuves, presentent les phénomenes décrits, il n'en est pas moins vrai que les vers en géneral, et plusieurs insectes, s'y sont refusés. J'ai essayé en vain les vers de terre, les sangsues, les limaces et limaçons, les huitres, et diverses chenilles; je n'y ai pas même pu exciter des mouvements par de petites et médiocres étincelles, et décharges, d'électricité artificielle. Voici de quelle manière j'ai procédé.

EXPERIENCE I. J'ai appliqué la feuille d'étain, et la lame d'argent, à différentes parties, tant exterieures qu'interieures, de ces limaces, sangsues, vers de terre, &c. et le mieux qu'il m'a été possible; et j'ai établi la communication de ces armures métalliques, tantôt en approchant l'une de l'autre jusqu'au contact, tantôt par l'intermede d'un autre métal faisant office d'arc conducteur; mais par tous ces moyens je n'ai jamais pu obtenir le moindre mouvement dans aucune partie de leur corps.

EXPERIENCE L. J'ai affectué à travers leurs corps, isolés ou non isolés, des décharges de bouteille assez fortes pour exciter une médiocre étincelle, et pour me donner une petite commotion, et ils n'en furent pas sensiblement affectés; point de mouvements ou des convulsions.

(36.) Est-ce donc que les animaux les plus imparfaits, la classe entière des vers, et plusieurs insectes ne possederoient gueres cette sensibilité et irritabilité, cette mobilité électrique,

s'il m'est permis de dire ainsi, dont jouissent les autres animaux plus parfaits? Je ne veux point encore tirer cette conclusion génerale de mes expériences, que je n'ai étendues jusqu'à présent qu'à un petit nombre de vers et d'insectes. Encore, à l'égard de ces derniers, je dois dire que j'ai réussi, sans beaucoup de difficulté, sur des ecrevisses, des scarabés, des sauterelles, des papillons, des mouches. Il ne sera pas inutile que j'explique une des manières par lesquelles je viens à bout avec ces animaux, difficiles d'assujettir aux expériences, ou par leur petitesse, ou par les écailles dont ils sont recouverts.

EXPERIENCE M. Après avoir tranché la tête à la mouche, au papillon, au scarabé, &c. je leur fend, tout au long, le corcelet avec un canif, ou de petits ciseaux; et j'introduis profondément dans la fente, près du cou, un morceau de feuille d'étain, (le papier dit improprement argenté est très à propos) et un peu au dessous j'introduis, de même bien avant dans l'intérieur, le tranchant d'une lame d'argent, ou d'une petite monnoye: alors quand j'avance celle-ci jusqu'au contact de la feuille d'étain, les jambes commencent à se plier, à se debattre, et les autres parties, et le tronc même, à s'agiter. Il est fort amusant d'exciter de cette manière le chant d'une cigale, &c.

(37.) Ainsi donc j'aurois grand tort de ranger les insectes parmi les animaux destitués, comme le sont les vers deja indiqués, de la faculté électrique dont il s'agit. Tout au plus, si les chenilles se montrent telles, on peut dire que dans cet état de larve, avant d'atteindre par leur métamorphose l'état parfait, d'acquerir de nouveaux organes, &c. de même qu'elles sont comparables aux vers à plusieurs autres égards,

elles le sont aussi à celui de n'être pas douées de la sensibilité électrique.

(38.) Enfin, s'il m'est permis de dire ici ce que je pense, les animaux seulement qui ont des membres bien distincts, des articulations, et des muscles propres pour le mouvement de chacun, de ces muscles qu'on appelle flexeurs, ou élevateurs, et des nerfs propres qui les regissent, se ressentent, et sont saisis d'une contraction reélle et spasmodique, soit par de petites décharges d'électricité artificielle, soit par un foible courant de fluide occasionné par les simples armures métalliques differentes; contractions et spasmes qui entrainent le mouvement, et aussi l'agitation violente des dits membres. Au contraire les vers, et ceux d'entre les insectes qui n'ont point de membres assez distincts, point d'articulations proprement dites, ou qui manquent de ces muscles flexeurs, ou qui ne jouissent que d'un mouvement vermiculair, ne sont point affectés par une semblable électricité. C'est une tout autre économie animale, une tout autre méchanique pour les mouvements de ces animaux, un jeu qu'on a très bien découvert et expliqué dans plusieurs espèces. Voila mes idées, encore un peu vagues, fondées sur quelques expériences; c'est la suite de celles-ci qui doit ou les confirmer, ou les rectifier.

(39.) A l'égard des différents muscles dans le même animal, je suis en état d'avancer quelque chose de plus assuré. Je dis donc, qu'il s'en faut de beaucoup que tous les muscles soient susceptibles de contraction par la foible action électrique dont il s'agit. Il y a une grande distinction à faire par rapport à leur fonction dans l'économie animale; tous ne sont pas soumis à l'empire de la volonté, et prêts aux mouvements spontanés. Or, il n'y a proprement que ceux-ci qui soient

capables des contractions spasmodiques, par les moyens décrits. Oui, il n'y a que les muscles obeissants à la volonté que j'ai trouvés susceptibles d'irritation et de mouvement, par l'action de ce foible courant de fluide électrique occasionné par le simple attouchement de deux métaux différents; et point du tout les autres muscles sur lesquels la volonté n'a aucun pouvoir direct, comme ceux du ventricule, des intestins, &c. pas même le cœur, d'ailleurs si irritable. Les muscles du diaphragme oui; (et je le devinai avant que d'en faire l'épreuve) puisqu'ils sont d'entre ceux dont les mouvements dépendent de la volonté.

EXPERIENCE N. Il est bien surprenant qu'une tranche de bonne chair musculaire, coupée, par exemple, à la cuisse d'un agneau égorgé une demie heure ou une heure avant; que ce morceau, dis-je, de muscle presqu'entièrement refroidi, et qui ne se ressent plus de l'action d'aucun stimulant méchanique ou chymique, soit si puissamment affecté par le fluide électrique transmi d'une partie à l'autre, au point d'être saisi de contractions spasmodiques très fortes; et qu'au contraire le cœur recemment arraché à ce même animal, et encore tout chaud et très irritable, traité de même, sollicité également par des armures métalliques le mieux adaptées, et l'arc conducteur qui en établit la communication, n'en souffre aucune altération; que ses battements lorsqu'ils sont affoiblis et lents ne redoublent point, et lorsqu'ils sont suspendus ou assoupis ne se reveillent pas, tandis que cela arrive par les plus foibles stimulants méchaniques, ou chymiques.

(40.) Le fluide électrique donc, qui paroît être le stimulant approprié aux muscles de la volonté, ne l'est aucunement pour le cœur, et pour les autres muscles doués des mouvements

vitaux et animaux non volontaires. Mais que dira-t-on si je montrerois qu'il n'est pas non plus la cause immédiate, ou efficiente, des mouvements des dits muscles volontaires; que dans ceux-ci mêmes il n'est encore qu'une cause médiate, entant que les nerfs seuls en sont directement affectés? C'est ce que plusieurs expériences m'ont appris; par lesquelles j'ai été forcé de renoncer aux plus belles et vastes idées. J'aimois à penser, avec Mr. GALVANI, que le fluide électrique mis en mouvement dans les organes, toutes les fois qu'il poussoit son courant jusqu'aux muscles, et qu'il les frappoit avec une certaine force, fit lui-même l'office de stimulant, et excitât l'irritabilité qui leur est propre; que tous les mouvements musculaires s'executassent par une semblable irruption de fluide électrique dans les muscles, soit lorsqu'on employoit l'électricité artificielle, soit lorsqu'on donnoit jeu à l'électricité animale naturelle; qu'enfin les mouvements mêmes qui se font naturellement dans la machine animale vivante, au moins les mouvements volontaires, reconnussent la même cause, savoir, l'action immédiate du fluide électrique sur les muscles. Mais, je le repéte, j'ai du renoncer, non sans regret, à toutes ces belles idées, par lesquelles il nous paroissoit possible d'expliquer les choses à merveille. Oui, il faut limiter beaucoup l'action de l'électricité dans les animaux, et l'envisager sous un autre point de vue, savoir, comme capable seulement d'exciter par elle-même les nerfs, comme j'ai déja indiqué, et comme je vais maintenant prouver.

(41.) D'abord qu'elle puisse agir, et qu'elle agisse effectivement, sur les nerfs, et que ceux-ci excités par elle excitent à leur tour les muscles dépendants, sans même que le courant électrique arrive jusqu'aux dits muscles, c'est un fait qui n'a plus

besoin de preuves après celles fournies par les Expériences A. et B. (sect. 19. et 20.) et même par une expérience de Mr. GALVANI, qui fut la première de toutes, et l'origine des autres, suivant son recit. On voit assez que le courant électrique, dans cette expérience du professeur de Bologne, comme dans les miennes que je viens de citer, traverse une partie seulement du nerf crural, et pas un des muscles de la jambe; cependant comme ils dépendent de ce nerf, ils tombent tous en convulsion.

(42.) Mais je vais plus avant et je soutiens, que même dans les cas où le courant électrique (on comprend bien que je n'entends parler que des foibles décharges artificielles, ou de ce courant qui a lieu par la simple application des armures de différents métaux) frappe et pénetre les muscles susceptibles de mouvement, ce n'est pas en irritant ceux-ci immédiatement qu'il les fait entrer en contraction, mais en stimulant leurs nerfs. C'est ce qu'indiquent déja mes Expériences C. et D. (sect. 21. et 23.) où la feuille d'étain et la lame d'argent se trouvant appliquées immédiatement aux parties musculeuses de l'animal, soit entier, soit écartelé, ce ne sont pas tant les muscles couverts par les deux armures métalliques qui souffrent les plus violentes contractions, que ceux qui dépendent de quelque nerf principal, auquel soit proche l'une ou l'autre des armures. C'est ainsi que dans la grenouille, lorsque la feuille d'étain est appliquée sur les reins, ou gissent à peu de profondeur les nerfs cruraux, les muscles des jambes sont saisis de fortes convulsions plus que tout autre, plus même que ceux qui touchent ou avoisinent l'autre armure, c'est à dire, la lame d'argent. J'ai déja fait observer la même chose dans les quadrupedes, chiens, agneaux, &c. par rapport au nerf ischiatique, (Expérience D.) et je dois ajouter seulement,

que la jambe ne laisse pas d'être sécouée lorsque ce nerf n'est pas trop caché sous les chairs et autres intéguments, et on applique comme il faut à cet endroit une des armures; quand même on ne feroit point repondre l'autre ni au muscle *gluteus*, ni à aucun muscle de la jambe, mais à un autre quelconque, pourvu qu'il ne soit pas trop éloigné. Voila encore pourquoi,

EXPERIENCE O. Si on applique à la grenouille, ou à d'autres petits animaux, la feuille d'étain tout le long de l'épine du dos, d'où sortent tous les nerfs du tronc et des membres; et l'autre armure à une autre partie quelconque, tous ces membres se debattent, les muscles, non seulement des jambes mais du ventre et du dos, souffrent des contractions spasmodiques, et le tronc lui-même se courbe et se plie en arc; en un mot les convulsions sont générales. L'expérience est encore plus frappante dans un lezard que dans une grenouille, et je vais la décrire.

EXPERIENCE P. Ayant coupé la tête à un lezard, et découvert les muscles du dos en enlevant la peau, j'applique un morceau de feuille d'étain au bout tronqué, de manière que cette feuille deborde un peu et s'éleve sur les épaules, et je pose une monnoye d'argent sur le milieu de l'épine; enfin je fais avancer, en glissant, cette monnoye jusqu'au contact de la dite feuille. A l'instant les jambes remuent, la queue se replie tortueusement, et tout le corps agité se courbe et s'élance de droite à gauche, et de gauche à droite. N'est-ce pas à cause que la partie supérieure de la moëlle épiniere, la source principale des nerfs, est irritée?

(43.) On peut obtenir, par une semblable opération, à-peu-près les mêmes effets dans une souris, un petit oiseau, &c.

mais il faut en ôter, non seulement la première peau et les autres intéguments, mais aussi de la chair, à raison que leur dos est plus charnu, et les principaux nerfs et la moëlle se trouvent plus cachés par cette chair, et par les os mêmes du tube vertebral. Il est aisé en effet de comprendre que le courant de fluide électrique, occasionné par les deux armures, ne penetrant qu'à une certaine profondeur les parties de l'animal recouvertes par ces armures, ne peut guere atteindre ni la moëlle épiniere, ni les principales branches des nerfs, qui entrent dans l'intérieur des membres, si les os, la chair, et d'autres intéguments interposés ont une epaisseur considerable. On comprend aussi pourquoi dans les grands animaux, chiens, agneaux, &c. on ne réussit pas à exciter de cette manière des mouvements dans tous les membres, je veux dire en appliquant les deux armures au dos, quoique décharné. Les gros troncs des nerfs restent encore trop cachés, et ensevelis; il n'y a que des branches ou ramifications qui gissent peu au dessous des dites armures, et ces branches n'aboutissent, pour la plus-part, qu'à certaines parties extérieures et voisines; en conséquence on ne voit naitre communément que des contractions et des palpitations superficielles dans tel ou tel autre muscle. Ou si par hazard tout un membre est mis en mouvement, c'est que le nerf qui entre dans son intérieur, et regit ce mouvement, se trouve peu caché, qu'il n'y a qu'un leger voile, une couche peu epaisse qui le couvre, des fibres minces seulement interposées entre lui et l'une ou l'autre des armures métalliques; comme on a pu observer dans les Expériences D. et suivantes, (sect. 23, &c.) où il suffisoit, pour exciter de grands mouvements dans la jambe d'un chien, ou d'un agneau, d'appliquer une des armures près du

nerf ischiatique, et plus on en approchoit, et plus on amincissoit la couche de chair qui l'enveloppoit, plus les mouvements de la jambe étoient forts.

(44.) Il faut donc connoître la position des nerfs, leur direction, &c. et il faut enlever non seulement les intéguments communs, la graisse, &c. mais aussi partie de la chair qui couvre et enveloppe les dits nerfs, il faut amincir plus ou moins cette enveloppe, avant que d'y appliquer l'armure métallique, pour obtenir dans les grands animaux le mouvement de tel ou tel autre membre, outre les contractions et palpitations superficielles de quelques muscles. Il est peut-être impossible d'exciter ces mêmes mouvements et convulsions dans tous les membres à la fois; tandis que cela n'est pas difficile dans les petits animaux, comme nous avons vu ci-dessus, (sect. 42. Expérience O. et P.) en leur ôtant seulement la peau, ou partie des autres intéguments; ce qui n'est pas même nécessaire pour la grenouille, à laquelle on peut laisser la peau, qui, étant extremement mince et humide, n'empêche pas par son interposition que le courant électrique atteigne les principaux nerfs, ou la moëlle épiniere.

(45.) Mais s'il faut avoir égard à la direction des principaux nerfs, pour determiner les mouvements dans les différents membres, il faut aussi faire attention à la position des armures relativement aux muscles; puisque ceux qui se trouvent interposés, et plus près de l'une ou de l'autre armure, sont en géneral plus sujets à contracter des convulsions spasmodiques, et souvent aussi sont les seuls dans lesquels on les observe; par exemple, lorsque les armures ne repondent à aucun gros nerf, ou, s'il y en a, lorsqu'ils se trouvent trop enveloppés et trop profondément cachés.

(46.) Cela, et les Expériences E. F. (sect. 28.) où un muscle seul, et même un morceau de muscle, traité à l'ordinaire, ne laisse pas de souffrir des contractions très fortes, pourroient faire croire que le fluide électrique produisît ces mouvements en irritant les fibres musculaires elles-mêmes, sans l'intervention des nerfs; l'action desquels par conséquent ne seroit ni *primaire*, ni absolument nécessaire, comme je prétends. Mais l'argument tiré de ces exemples n'a aucune force, tant qu'on ne prouve pas que dans ces muscles, dans ces morceaux de muscle, il n'y ait gueres de nerfs; puisque s'il y en a, (et certainement il doit y avoir, et il y a, des ramifications nerveuses dans chaque portion sensible, j'ai presque dit dans chaque fibre musculaire) je puis toujours soutenir que ce sont ces filets nerveux, dont la substance du muscle se trouve parsemée, qui sont immédiatement affectés par le fluide électrique qui pénetre cette même substance; que ce fluide déployant son action sur les nerfs extremement sensibles, action qui finit là, ceux-ci exercent la leur sur les muscles, &c. Je puis, dis-je, soutenir avec assez de vraisemblance que le fluide électrique n'a par lui-même d'influence au phénomene des contractions musculaires, qu'en ce qu'il en excite les nerfs; en un mot, qu'il n'en est pas la cause immédiate. Une telle assertion, que les choses expliquées jusqu'ici rendent plus que probable, est prouvée directement, et de la manière la plus évidente, comme je vais montrer, par plusieurs expériences que j'ai faites sur la langue: expériences qui m'ont conduit à d'autres découvertes, aussi intéressantes que curieuses.

(47.) Etant parvenu à exciter des convulsions toniques, et les mouvements les plus forts, dans les muscles, et dans les membres, non seulement des petits mais des grands animaux, sans

découvrir aucun nerf, par la simple application des armures de différents métaux aux muscles denués des intéguments, je pensai bien-tôt si on ne pourroit pas obtenir la même chose dans l'homme. Je conçus que la chose réussiroit très bien dans les membres amputés; mais dans l'homme entier et vivant comment faire? Il auroit fallu aussi ôter les intéguments, faire des incisions profondes, emporter même une partie des chairs aux endroits sur lesquels on alloit appliquer les lames métalliques, (comme j'ai fait remarquer qu'il faut faire souvent aux parties charnues des grands animaux). Heureusement il me vint dans la tête, que nous avons, dans la langue, un muscle nu, dépourvu au moins des intéguments épais dont sont couvertes les parties extérieures du corps, un muscle qui est très mobile, et mobile à volonté. Voila donc, me disois-je, toutes les conditions requises, pour pouvoir y exciter de vifs mouvements par l'artifice ordinaire des armures différentes. Dans cette vue je fis, sur ma propre langue, l'expérience suivante.

(48.) EXPERIENCE Q. Ayant revêtu la pointe de la langue, et une partie de sa surface superieure, dans l'étendue de quelques lignes, d'une feuille d'étain, (le papier dit argenté est le plus à propos) j'appliquai la partie convexe d'une cuiller d'argent plus avant sur le plat de la langue, et en inclinant cette cuiller je portai sa queue jusqu'au contact de la feuille d'étain. Je m'attendois à voir tremblotter la langue; et je faisois, pour cela, l'expérience devant un miroir. Mais les mouvements que j'osois prédire n'arriverent pas; et j'eus, au lieu de cela, une sensation à laquelle je ne m'attendois nullement; ce fut un goût aigre assez fort, sur la pointe de la langue.

(49.) Je fus d'abord fort surpris de cela; mais réfléchissant un peu à la chose, je conçus aisément, que les nerfs qui aboutissent à la pointe de la langue, étant les nerfs destinés aux sensations du goût, et nullement aux mouvements de ce muscle flexible, il étoit tout-à-fait naturel, que l'irritation du fluide électrique, mu par l'artifice ordinaire, y excitât une saveur, et pas autre chose; et que pour exciter dans la langue les mouvements dont elle est susceptible, il faudroit appliquer une des armures métalliques auprès de sa racine, où s'implantent les nerfs destinés à ces mouvements; ce que je verifiai bientôt par cette autre expérience.

(50.) EXPERIENCE R. Ayant coupé, à un agneau tout recemment égorgé, la langue près de sa racine, j'appliquai une feuille d'étain à l'endroit de la coupure, et la cuiller d'argent à une de ses surfaces; procedant alors à établir une communication, comme il faut, entre ces deux armures métalliques, j'eus le plaisir de voir la langue entière tremousser vivement, élever sa pointe, se tourner et se replier de part et d'autre, chaque fois et tout le tems qu'une telle communication avoit lieu.

(51.) J'ai répété cette expérience sur une langue de veau, que je posai, armée de la même manière de la feuille d'étain près de sa racine, sur un plat d'argent, pour qu'il fît l'office de l'autre armure; et le succès fut le même. Je l'ai répétée aussi sur la langue d'autres petits animaux, comme souris, poulets, lapins, &c. et j'obtins presque toujours le même effet. Je dis presque toujours, car quelques fois il manqua dans la langue des petits animaux; soit que la feuille d'étain ne fût pas appliquée convenablement à l'endroit juste, où les nerfs qui

regissent les mouvements de la langue y ont leur insertion; soit que la langue refroidie eût déja perdu sa vitalité, qui ne dure gueres long-tems dans les muscles des animaux à sang chaud, comme j'ai déja fait observer, (sect. 26.) et particulièrement dans la langue.

Je suis, &c.

A. VOLTA.

Octobre 25, 1792.

V. *Further Particulars respecting the Observatory at* Benares, *of which an Account, with Plates, is given by Sir* Robert Barker, *in the LXVIIth Vol. of the Philosophical Transactions. In a Letter to* William Marsden, *Esq. F. R. S. from* John Lloyd Williams, *Esq. of* Benares.

Read January 31, 1793.

DEAR SIR,

In conformity with your request, I have now the pleasure of sending you an account of the measurement of the different parts of the Benares observatory, called *maun-mundel*, as taken by myself, with a two-foot rule, and a rod of ten feet very exactly divided. An account of the use of the different instruments, though very imperfect, was given me on the spot, by several learned Brahmins who attended me; one of whom is professor of astronomy in the new founded college at Benares. They all agreed that this observatory never was used, nor did they think it capable of being used, for any nice observations; and believe that it was built more for ostentation, than the promotion of useful knowledge.

In my inquiry into the particulars of the building, I have been assisted by my friend the Nabob Ali Ibrahim Kaun, and I believe this account may be relied on.

A.* The large quadrant, called in Arabic, *kootoop-bede*; in Hindoo, *droop*, the name of the north polar star. This instrument is built of stone, fixed in mortar, and clamped with iron in a very clumsy manner; between most of the stones are spaces of $\frac{1}{16}$ part of an inch. The stile, in its length from north to south, measured 39 feet $6\frac{1}{2}$ inches; the height of the south end, 5 feet $4\frac{1}{4}$ inches; height of the north end, 22 feet 3 inches. This stile consists of two walls $11\frac{1}{2}$ inches thick, with a flight of 27 steps between; and on the outer edge of each of these walls are fixed two iron rings. The distance between the two rings is 5 feet $8\frac{1}{2}$ inches; from the uppermost to the top, 18 feet 8 inches; from the lower one to the bottom, 15 feet and $\frac{1}{2}$ an inch; both sides are nearly alike. The rings are, each of them, $\frac{3}{4}$ of an inch in thickness, and they are let into the wall between two stones; the holes through which the object is to be viewed are $\frac{1}{16}$ths of an inch in diameter, $\frac{1}{4}$ths of which space, in each, is covered by the projection of the stone. The radius of one of the quadrants, on which the hour lines are marked, from the outer part of the wall of the stile to the inner edge of the arc, is 9 feet and $\frac{1}{4}$ths of an inch; that of the other, 9 feet one inch. The width of the rim of the quadrants, which are inclined to a line perpendicular to the shadow falling from the gnomon, is 5 feet $10\frac{1}{4}$ inches. The quadrant is divided into 6 *gurries*, and each *gurry* into 10 *pulls*.

On the outer wall of the stile, fronting the east, at the

* The references are to the plates annexed to Sir ROBERT BARKER's account.

height of 10 feet and 10 inches from the base, are fixed two iron pins, each forming a centre, from which circular lines are drawn, intersecting each other, as in the annexed representation;

with a parallel line drawn underneath, which has the hour, or *gurry* and *pull* lines marked on it. The wall is plastered; and there are, on other edifices fronting the east, similar lines drawn; the use of which, I understood, was to ascertain the time of the day.

B. An equinoctial dial, called *gentu-raje*.—It is a circular stone, fronting north and south, but inclining towards the south. The diameter of the south face is 2 feet 2¼ inches, a perpendicular line falling from the top will give one foot distance from the bottom of the inclined plane. In the south front of this stands a small stone pillar, distance 3 feet 8 inches; a line drawn from the centre of this dial to the point on the top of the pillar, will, by its shadow, give the time of the day. On the *nadir* side of this dial, the stone is 4 feet 7 inches diameter; on the centre of which is a small iron stile, with a hole in it, perpendicular to its plane; and in the perpendicular line of the chord are placed two small irons. A line passing through the hole in the stile, and each end applied to the forementioned irons, gives a shadow, which denotes the hour, &c.

C. A brass circle in the line of the equator, facing north

and south. It has a moveable index, turning on a pivot in the centre; the circle is divided into 360 degrees, or *unse*, subdivided again into 60′, and again into 6″, and into $\frac{1}{4}$ths. This instrument is called *cund-brit*, or *cranti-brit*, but I could not learn the use of it.

D. A double circular wall, with a round pillar in the centre, as described by Sir ROBERT BARKER. The floor being broken, and uneven, renders the height of the outer wall irregular, but it measured from 8 feet 1 inch, to 8 feet 3 inches; diameter inside, 27 feet $6\frac{1}{2}$ inches; thickness of the wall, 2 feet. The inner wall is 18 feet within; thickness of this wall, 1 foot $5\frac{1}{2}$ inches. The diameter of the centre pillar, 3 feet $7\frac{1}{2}$ inches.

At the four cardinal points, on the top of the outer wall, are four iron pins, with small holes in them, through which, the Pundits say, wires are designed to be drawn at the time of observation, which wires intersect each other at the centre of the pillar. The tops of both the walls are graduated, or divided into degrees; and it is said, that by the shadow of these wires falling on the walls, the sun's declination is found.

In addition to the foregoing, which are described in the plates alluded to, on the south-east quarter of the building is a large black stone, 6 feet 2 inches diameter, fronting the west; it stands on an inclined plane. I could not learn the use of this instrument; but was informed that it never had been completed. There is no other building of any consequence, nor does it appear there ever was.

I fear, that from the want of sufficient knowledge of the science of astronomy, I have not been able to describe the

different instruments, and their uses, satisfactorily; however, you may rely on the measurements being taken with the greatest exactness.

For the following description I am indebted to our chief magistrate, the Nabob ALI IBRAHIM KAUN.

"The area, or space comprising the whole of the buildings and instruments, is called in Hindoo, *maun-mundel*; the cells, and all the lower part of the area, were built many years ago, of which there remains no chronological account, by the Rajah MAUNSING, for the repose of holy men, and pilgrims, who come to perform their ablutions in the Ganges, on the banks of which the building stands.

"On the top of this the observatory was built, by the Rajah JEYSING, for observing the stars, and other heavenly bodies; it was begun in 1794 Sumbut, and, it is said, was finished in two years. The Rajah died in 1800 Sumbut.

"The design was drawn by JAGGERNAUT, and executed under the direction of SADASHU MAHAJIN; but the head workman was MAHON, the son of MAHON a pot-maker of Jeypoor. The pundit's pay was five rupees per day; the workmen's two rupees, besides presents; some got lands, or villages, worth 3 or 400 rupees yearly value; others money."

I am, &c.

Benares
March 25, 1792.

J. LL. WILLIAMS.

VI. *Extracts of two Letters from the Rev.* Edward Gregory, *M. A. Rector of* Langar, Nottinghamshire, *to the Rev.* Nevil Maskelyne, *D. D. F. R. S. Astronomer Royal; containing an Account of the Discovery of a Comet, with Observations thereon.*

Read February 7, 1793.

Extract of the first Letter, dated Langar, *near* Nottingham, January 10th, 1793.

I TROUBLE you with this letter to communicate to you such observations as I have made of a comet, which I saw on the 8th instant. The evening of the 8th being very clear, I was employed in my observatory, in taking differences of right ascension and declination between the planet Venus and ϑ Aquarii, when, happening to look towards the north-west part of the hemisphere, I saw a star of a hazy appearance, and about the size of a star of the second magnitude, in the space between the flexure of the Dragon and the foot of Hercules, larger and brighter than I had before remarked in that part of the heavens; which excited my attention so much, as to induce me to direct such a telescope to it as lets in much light, and is generally used at sea to see objects in the night. This star seemed to have a hazy and indistinct appearance in the telescope, which immediately led me to suspect it might be a comet; but the twilight yet remaining, I was not quite

certain of it. When the night was completely come on, it became evident it was a comet, the coma being of a white light, hazy, and ill defined. I could perceive no nucleus, nor as yet any appearance of a tail.

I waited for, and was fortunate enough to obtain, an observation of its passage over the meridian under the pole, at 4^h 8′ 30″ by EARNSHAW's clock, or 4^h 6′ 43″ sidereal time; its zenith-distance, by BIRD's quadrant, being 75° 16′ 16″. The observation of the passage over the meridian was taken by guessing when a hazy dim appearance, about the shape and size of a hen's egg, was in the centre of the field of the transit instrument; any light, however weak, effacing all the light of the comet.

These observations were merely formed from the best judgment I could make by the naked eye, for, as I before observed, the light of the comet was so weak, as not to bear any degree of light sufficient to render visible the wires in the night telescope; which I have mounted on a polar axis, with a proper system of wires to take differences of right ascension and declination.

I continued to watch the comet until three o'clock in the morning, when it had ascended to some considerable altitude; I could perceive with the night telescope a very faint, but yet sufficiently evident tail, and that the comet had moved a few minutes to the west; that is, had increased its right ascension, and also its polar distance. I then observed the comet with other telescopes, of less aperture and deeper powers; in such it appeared a confused white hazy light, nor could I perceive any nucleus or tail, although it was visible in the night-glass, with its direction towards the zenith.

In case you are already apprised of the appearance of this comet, and of course this information is superfluous, I hope you will attribute my giving you this trouble to my eager desire that these extraordinary bodies may be observed with such capital instruments as you are in possession of, and also to shew you, by these attentions, the sense I entertain of the many civilities I have received from you.

I am, &c.

EDWARD GREGORY.

On the 9th I obtained a very imperfect glimpse of the comet, the twilight yet being very considerable, and the air very hazy. The comet has moved considerably westward, and its polar distance, I think, is increased. I thought the tail appeared rather brighter and longer; the coma not altered; no nucleus to be seen. This observation was extremely imperfect, the comet being seen with the night-glass held in my hand, during a space of four or five minutes: the sky, in that part, was cloudless, though most of the surrounding constellations were obscured.

Extract of the second Letter, dated January 25*th*, 1793.

THE observations of the comet were taken after the following manner. Finding that any degree of light sufficient to render the wires visible effaced the comet, I brought it, as nearly as I could judge, into the centre of the field without using any light, and then cast light on the illuminator; and in that stage of the process between the comet's disappearing and the wires becoming visible, I trusted to the impression left on the eye for the place of the comet when it vanished; and

I think I could not err more than three or four minutes from its being on the middle horizontal wire, and about as much from the intersection of the vertical, with the middle horizontal wire. But, after all, it is a vain thing to talk of critical exactness in this matter, either in the quadrant or transit observations, under the circumstances I am going to describe to you. The comet, in the telescopes of these instruments, had somewhat the appearance of a hen's egg, seen obliquely, with the large end towards the eye; of a dull white misty light. I could perceive no nucleus, therefore I considered the longest diameter, which was nearly directed towards the east, (but there was hardly any perceivable difference in the diameters) as the line in which, had any nucleus been visible, it would have been found; and I endeavoured, in the manner I have described, to bring this line on the middle horizontal wire, and the brightest part of it up to the vertical wire; and when I thought I had effected this, I read off the divisions on the arch, and noted the time by EARNSHAW's regulator.

On January 21st, I observed the instantaneous immersion of γ Tauri, at $0^h\ 54'\ 22''$ by my clock; and at $2^h\ 3'\ 31''$ I saw it again about a minute's distance from the moon's enlightened limb, the moment of emersion having escaped observation. I had, on the same day, observed the sun's passage over the meridian, by a mean of the wires, at $20^h\ 18'\ 45\frac{1}{3}''$; the clock had been losing a little more than a second a day, for eight or ten weeks past.* The mean of ten observations of the first satellite

* Hence the immersion of the star was at $4^h\ 34'\ 48'',6$, and the first sight of it after the emersion at $5^h\ 43'\ 46''$, apparent time. This may perhaps be useful in determining the longitude of Mr. GREGORY's observatory.—Note by Dr. MASKELYNE.

of Jupiter place me 3′ 47″, in time, west of Greenwich. My latitude, deduced from a great number of observations of the sun and stars, in all the various ways of determining the latitude, with BIRD's quadrant, HADLEY's quadrant, and two equatorial instruments, is 52° 54′ 37″ N.

It remains that I relate what I saw of the comet's tail. At 15^h astronomical time of the 8th, or three o'clock civil time in the morning of the 9th, I saw a very faint beam of light extending itself from the coma towards the zenith. When I brought the coma to the centre of the field of the night-glass, which takes in about 7 degrees, it reached to near the circumference of the field, consequently it amounted to about 3½ degrees. I thought it brighter and longer when I had a mere glimpse of the comet in the evening twilight on the 9th. On the 10th, 11th, and 12th, the tail was rather brighter, yet very faint; not broader than a finger, nor brighter than a beam of light let into an ill darkened room for prismatic experiments. It extended itself beyond the circumference, when the coma was in the centre of the night-glass, perhaps a degree, consequently was 4°½ long; it was inclined towards the east, and on the 12th pointed due east at midnight.

On the 11th, the comet passed the middle wire of the transit instrument under the pole, at 8^h 28′ 0″ sidereal time. The zenith distance was 56° 2′ 15″.

I am, &c.

EDWARD GREGORY.

VII. *Observations of the Comet of* 1798, *made by the Rev.* Nevil Maskelyne, *D. D. F. R. S. Astronomer Royal, and other Observers. Communicated by the Astronomer Royal.*

Read February 14, 1798.

1793.	Mean Time at Greenwich.	Æ of Comet in sidereal Time.	Æ of Comet in Degrees, &c.	Declination of Comet.	Longitude of Comet.	Latitude of Comet.	Name of Observers.
Jan^{y}.	H. M. S.	H. M. S.	S. ° ′ ″	D. M. S.	S. D. M. S.	D. M. S.	
8	8 55 7	16 6 43	8 1 40 45	51 46 23 N	7 2 29 3	69 38 5 N	Mr. Gregory.
11	13 3 50	20 27 56	10 6 59 0	71 1 42 N	1 5 16 0	76 9 8 N	
14	11 38 0	1 12 48	0 18 12 0	45 53 12 N	1 6 16 29	34 53 33 N	Mr. Steph. Lee.
18	9 26 6	1 58 28,6	0 29 37 9	17 47 7 N	1 3 45 36	5 19 33 N	
21	8 5 52	2 11 42,8	1 2 55 42	9 1 26 N	1 3 47 57	4 0 25 S	The Astronomer Royal.
26	6 54 35	2 22 42,23	1 5 40 33	1 48 19 N	1 3 58 51	11 43 25 S	
27	7 37 41	2 24 4,19	1 6 1 3	0 51 36 N	1 3 59 30	12 43 44 S	
28	6 56 35	2 25 18,35	1 6 19 35	0 4 11 N	1 4 1 22	13 34 36 S	
30	8 57 38	2 27 41,4	1 6 55 21	1 20 59 S	1 4 7 13	15 6 48 S	
Feb.							
3	7 11 52	2 31 27,2	1 7 51 48	3 17 27 S	1 4 22 44	17 15 20 S	
4	7 4 12	2 32 17,2	1 8 4 18	3 40 40 S	1 4 27 4	17 41 21 S	
5	7 42 28	2 33 5,13	1 8 16 17	4 2 42 S	1 4 31 19	18 6 6 S	
7	8 5 26	2 34 37,55	1 8 39 23	4 41 11 S	1 4 40 55	18 50 1 S	

These places of the comet may admit of some little change, when the stars with which it was compared have been settled by observations with the meridian instruments.

VIII. *Account of the Method of making Ice at* Benares. *In a Letter to* William Marsden, *Esq. F. R. S. from* John Lloyd Williams, *Esq. of* Benares.

Read February 14, 1793.

DEAR SIR,

As the method of making ice in this country, where the thermometer, during part of the year, stands at from 95 to 100° in the shade, has something peculiar in it, I trust the following description of the process will not be unacceptable.

You know that ice is made in India during the months of December, January, and part of February; but I believe it has generally been considered as necessary to the congelation of the water, that it should have been boiled. However, I can now assure you, as a fact within my own observation for these nine years past, that a large quantity of ice has been made at this place every year, without any preparation whatever; and I have often seen ice of an inch and quarter thick, notwithstanding I do not conceive that the atmosphere, at that time, was sufficiently cold to produce the effect; for I have frequently placed a thermometer, with the naked bulb on the straw, amidst the freezing vessels during the night, and on inspecting it between five and six o'clock in the morning (at which time the ice-makers informed me the cold was most intense), I never found it below 35°. I

have even seen ice, of a considerable thickness, formed when the thermometer was not lower than 40 degrees.

The method of making ice at Seerore, near Benares, is as follows.

A space of ground of about four acres, nearly level, is divided into square plats, from four to five feet wide. The borders are raised, by earth taken from the surface of the plats, to about four inches; the cavities are filled up with dry straw, or sugar-cane haum, laid smooth, on which are placed as many broad shallow pans, of unglazed earth, as the spaces will hold. These pans are so extremely porous, that their outsides become moist the instant water is put into them; they are smeared with butter on the inside, to prevent the ice from adhering to them, and this it is necessary to repeat every three or four days; it would otherwise be impossible to remove the ice without either breaking the vessel, or spending more time in effecting it than could be afforded, where so much is to be done in so short a time. In the afternoon these pans are all filled with water, by persons who walk along the borders or ridges. About five in the morning, they begin to remove the ice from the pans; which is done by striking an iron hook into the centre of it, and by that means breaking it into several pieces. If the pans have been many days without smearing, and it happens that the whole of the water is frozen, it is almost impossible to extract the ice without breaking the pan. The number of pans exposed at one time, is computed at about 100,000, and there are employed, in filling them with water in the evenings, and taking out the ice in the mornings, about 300, men, women, and children; the

water is taken from a well contiguous to the spot. New vessels, being most porous, answer best.

It is necessary that the straw be dry; when it becomes wet, as it frequently does by accident, it is removed, and replaced. I have observed water which had been boiled, freeze in a china plate; yet having frequently placed a china plate, with well-water, among the unglazed pans on the straw beds, I found that when the latter had a considerable thickness of ice on them, the china plate had none. I have also wetted the straw of some of the plats, and always found it prevented the formation of ice. The air is generally very still when much ice is formed; a gentle air usually prevails from the south-westward about daylight. I had a thermometer among the ice pans, during the season of making ice, with its bulb placed on the straw, and another hung on a pole $5\frac{1}{2}$ feet above the ground; and commonly observed, that when ice was formed, and the thermometer on the straw was from 37 to 42°, that on the pole would stand about 4 degrees higher; but if there was any wind, so as to prevent freezing, both the thermometers would agree.

I shall offer no opinion respecting the causes of ice being formed when the thermometer is so many degrees above the freezing point; but hope the subject will be elucidated by some more capable person.

I am, &c.

Benares,
March 25, 1792.

J. LL. WILLIAMS.

IX. *Account of two Instances of uncommon Formation, in the Viscera of the Human Body.* By Mr. John Abernethy, *Assistant Surgeon to St.* Bartholomew's *Hospital. Communicated by Sir* Joseph Banks, *Bart. P. R. S.*

Read February 14, 1793.

I TAKE the liberty of presenting to the Royal Society, the relation of two cases of uncommon formation of the human body. When animal existence is supported by any other than the usual admirably contrived means, it cannot fail to excite the attention of the philosopher, since it shews to him the powers and resources of nature.

The peculiarities of the first case which I have the honour to offer to the Society, consist in an uncommon transposition of the heart, and distribution of the blood vessels; together with a very strange, and, I believe, singular formation of the liver. The body which contained these deviations from the usual structure was brought to me for dissection; with its history whilst alive, I am therefore unacquainted. The subject was a female infant, which measured two feet in length; the umbilicus was firmly cicatrized, and the umbilical vein closed; from these circumstances I conclude that it was about ten months old. The muscles of the child were large and firm, and covered by a considerable quantity of healthy fat; indeed the appearance of the body strongly implied that the child had, when living, possessed much vigour of constitution.

I shall first relate those varieties of the sanguiferous system which were found on the thoracic side of the diaphragm, and afterwards describe those which were discovered in the abdomen; this will naturally lead me to the account of the uncommon state of the liver. The situation of the heart was reversed; the basis of that organ was placed a little to the left of the sternum, whilst its apex extended considerably to the right, and pointed against the space between the sixth and seventh ribs. The cavities usually called the right auricle and ventricle were consequently inclined to the left side of the body; therefore, to avoid confusion in the description, I shall, after Mr. WINSLOW, term them anterior, whilst those cavities usually called left, I shall term posterior. The inferior vena cava past, as usual, through a tendinous ring in the right side of the centre of the diaphragm, it afterwards pursued the course of the vena azygos, the place of which it supplied; after having united with the superior cava, the conjoined veins passed beneath the basis of the heart, to expand into the anterior auricle. The veins returning the blood from the liver united into one trunk, which passed through a tendinous aperture in the left of the centre of the diaphragm, and terminated immediately also in the anterior auricle.

The distribution of blood to the lungs, and the return of it from those bodies, were accomplished after the usual manner.

The aorta, after it had emerged from the posterior ventricle of the heart, extended its arch from the left to the right side, but afterwards pursued its ordinary course along the bodies of the dorsal vertebræ.

From the curvature of the aorta there first arose the common arterial trunk, which, in this subject, divided into the left carotid and subclavian arteries; whilst the right carotid, and subclavian, proceeded from the aorta by distinct trunks.

The inferior aorta gave off the cœliac, which, as usual, divided into three branches; however, that artery which was distributed to the liver appeared larger than common; it exceeded, by more than one-third, the size of the splenic artery of this subject. This was the only vessel which supplied the liver with blood, for the purpose either of nutrition or secretion.

The vena portarum was formed in the usual manner, but terminated in the inferior cava, nearly on a line with the renal veins. The umbilical vein of this subject ended in the hepatic vein.

The liver was of the ordinary size, but had not the usual inclination to the right side of the body; it was situated in the middle of the upper part of the abdomen, and nearly an equal portion of the gland extended into either hypochondrium.

The gall bladder lay collapsed in its usual situation; it was of a natural structure, but rather smaller than common; it measured one inch and a half in length, and half an inch in breadth. On opening the bladder, we found in it about half a tea-spoon full of bile; in colour it resembled the bile of children, being of a deep yellow brown; it also tasted like bile; it was bitter, but not so acridly or nauseously bitter as common bile.

I diluted a small quantity of this fluid with water, and with this liquor moistened some paper which had been tinged with a vegetable blue; this was instantly changed

into a deep green, consequently this fluid, like common bile, abounded with alkali. I added some diluted nitrous acid to a small quantity of this, and of common bile; they both became changed, by this addition, to a similar green colour. The colouring matter of the bile therefore appears to have possessed its common properties.

The gall ducts had been divided, in removing the stomach and duodenum, before the uncommon termination of the vena portarum was discovered, and some bile had flowed from the divided ducts.

The intestines did not contain much alimentary or fœcal matter; this was, however, as usual, deeply tinged with bile.

The spleen consisted of seven separate portions, to each of which a branch of the splenic artery was distributed. The other viscera were sound, and of their usual structure and appearance.

No cause could be discovered to which the child's death could be assigned. We observed that the tongue was incrusted with a dark coloured mucus, which indicated the existence of fever previous to the infant's death.

When an anatomist contemplates the performance of biliary secretion by a vein, a circumstance so contrary to the general economy of the body, he naturally concludes, that bile cannot be prepared unless from venal blood; and he also infers, that the equal and undisturbed current of blood in the veins is favourable to the secretion; but the circumstances of the present case, in which bile was secreted by an artery, prove the fallacy of this reasoning. I extremely regret that only so small a quantity of this bile could be collected from the gall bladder; as, surely, it was very desirable to ascertain

more fully how far the qualities of this curiously prepared fluid resembled common bile.

That the fluid secreted by the liver was not, in this case, deficient in quantity, appears to me sufficiently evident. If the gall bladder had not suffered occasional repletion, I think it would have been found in a state of greater contraction. Some bile had escaped from the divided gall ducts, and a considerable quantity of this fluid would be required to give so deep a tint, as in this case was visible, to the alimentary matter.

I cannot, therefore, but suppose that the empty state of the gall bladder was the effect of accident, and not of deficient secretion by the liver. The bulk and well nourished state of the body do, I think, demonstrate that there was no defect in the functions of the chylopoetic organs.

But it will surely be inquired, from what cause the death of the child originated. It may be suspected that the mal-formation of the liver contributed to its decease; and particularly as no derangement of any vital organ could be discovered. Yet if it be considered how frequently children die from nervous irritation, or fever, the probability of this suspicion is, in my opinion, diminished. The circumstances of the case may impress others with contrary sentiments; I shall remain satisfied with having faithfully described the appearances of the body, and having offered those remarks which I believed deducible from them.

The peculiarity of the next case, which I have the honour to lay before the Society, consists in an uncommon formation of the alimentary canal. The body of a boy was brought to me for dissection; it measured four feet three inches in

length; it was well formed, and had moderately large limbs; they, however, appeared flabby, as if wasted by recent disease.

The abdomen was enormously swoln; which being opened, there appeared a more than ordinary extent of large intestines, in a state of great distention.

The diameter of the canal measured about three inches, and its dimensions were nearly equal in every part.

The matter with which it was turgid was of a greyish colour, of a pulpy consistence, having little fœtor, and quite unlike the usual fœcal contents of the large intestines.

The length of the colon was uncommon; having, as usual, ascended to the right hypochondrium, it was reflected downwards, even into the pelvis; it then reascended to the left hypochondrium, and afterwards pursued its usual course.

After turning aside this large volume of intestine, to examine the other parts of the alimentary tube, we were surprised to discover that the subject contained scarcely any small intestines. These viscera, with the stomach, lay in a perfectly collapsed state; their texture was extremely tender; they were torn even by a gentle examination. The duodenum, jejunum, and ileum, when detached from the body, and extended, measured only two feet in length, whilst the extent of the large intestines exceeded four feet.

The utmost length of the intestinal tube, in this subject, was little more than six feet, whereas it should have been about twenty-seven feet, had it born the ordinary proportion to the length of the body.

I distended and dried this curious alimentary canal, and still have it in preservation.

As the small intestines measured only two feet in length,

this extent was doubtless insufficient for the preparation and absorption of chyle; these processes must therefore have been, in a great degree, performed by the large intestines.

The form and stature of the boy shew that nutrition was not scantily supplied; he died evidently from a want of intestinal evacuation. Whether the unusual structure of the canal contributed to the production of disease, cannot, perhaps, be readily determined; it appears, however, very probable that uncommonly formed parts, although capable of supporting life, may be less adapted to sustain the derangement of functions consequent to disease.

In Tab. VII. and VIII. are represented the appearances described in the first of the foregoing cases.

Tab. VII.

A. The anterior ventricle, which is usually inclined to the right side.

B. The anterior auricle.

C. The posterior ventricle, which is usually inclined to the left side.

D. The posterior auricle.

E. The superior vena cava.

F. The aorta.

G. The pulmonary artery.

H. The common trunk of the left carotid, and subclavian arteries.

I. The right carotid.

K. The right subclavian.

L. The hepatic vein.

M. Part of the diaphragm.

N. The liver.
O. The superior mesenteric artery.
P. The renal artery.
Q. The renal vein.
R. The vena cava inferior.
S. The aorta continued.
T. T. The vena portarum.

Tab. VIII.

A. The anterior auricle, turned backwards, that the vena cava may be seen.
B. The posterior ventricle.
C. The posterior auricle.
D. The superior vena cava.
E. The inferior vena cava.
F. The conjoined veins passing beneath the basis of the heart to the anterior auricle.
G. The beginning of the vessels of the right lung.
H. The pulmonary artery.
I. The aorta.
K. The hepatic vein.
L. Part of the diaphragm.
M. The liver.
N. The cæliac artery.
O. The hepatic artery.
P. The splenic artery.
Q. The renal artery.
R. The superior mesenteric artery.
S. The renal vein.
T. T. The vena portarum.

Basire sc.

Basire. Sc.

X. *An Account of the Equatorial Instrument.* By Sir George Shuckburgh, *Bart. F. R. S.*

Read March 21, 1793.

" Juvat ire per altum
" Aëra, et immenso spatiantem vivere cœlo;
" Hoc sub pace vacat tantum." MANILIUS, lib. i.

(1.) BEFORE I enter upon the description of the instrument which I propose particularly to describe, it may not be improper to say something of the equatorial in general, and of such instruments as, having been made upon a similar principle, have been used by different astronomers, in different ages.

The first account, that I meet with, of an astronomical instrument that bears any resemblance to it, is to be found in PTOLEMY, (lib. 5 of his Almagest) wherewith, he tells us, he determined the distance between the two tropics. This instrument is described under the name *αστρολαβικον οργανον*, and appears to have consisted of two circles, placed at right angles to each other, one representing the meridian or solsticial colure, and the other the zodiac; the former turning upon an axis, placed parallel to the axis of the earth, being elevated to the latitude of the place, and the other turning within it on two centres, removed $23\frac{1}{2}^{\circ}$ from the former axis; and was in truth not very unlike the common ring dial, only

about six times as large. Each circle was divided into 360°, and those again into three or four subdivisions, and being furnished (it may be supposed) with moveable sights, the observer was enabled to take the elevation or depression of any object above or below the ecliptic, together with its distance from the meridian, or colure, that circle being previously placed parallel to its corresponding one in the heavens. The first measure would give the latitude of any heavenly body, and the latter the longitude. This instrument, or something similar to it, seems to have been in use as early as the time of HIPPARCHUS, who lived in the second century before our Saviour, (vide WEIDLERI *Hist. Astron.* p. 319; et TYCHONIS BRAHE *Mechanica*) and was continued to be used by astronomers for upwards of fifteen centuries afterwards.

(2.) The next account that occurs is by J. MULLER, REGIOMONTANUS, sive JOANNES de Monte Regio, who flourished about A. D. 1460, and, in a posthumous treatise expressly on this subject, intitled *Scripta clarissimi Mathematici* M. JOANNIS REGIOMONTANI *de Torqueto, Astrolabio armillari, Regulâ magnâ Ptolemaici, Baculoque Astronomico, &c. &c.* in quarto, printed at Nuremberg in 1544, has given a pretty full account, not only of the armillary astrolabe, but also of the *torquetum*, which in fact was nothing more than a portable equatorial, and may be considered as the first instrument truly of this kind. As this treatise is become extremely scarce, and I know of only one copy in this kingdom, I take this opportunity of apprizing the curious, that it is to be met with in the British Museum. A short description, however, of the *torquetum*, with a plate of the instrument, will be found in Mons. BAILLY'S *Astro-*

nomie Moderne, Tome I. p. 687; and a description of the *astrolabium armillare* of PTOLEMY, according to REGIOMONTANUS's conception of it, who may be considered as the best commentator upon the Almagest now to be met with, will be found in WEIDLER's *Historia Astronomiæ*, quarto, 1741.

(3.) The next author that presents himself is COPERNICUS, (who lived in 1530) and in his work *De Revolutione Orbium cælestium*, lib. 2. c. 14. *De exquirendis Stellarum Locis*, professedly describes the same instrument with PTOLEMY; but, as it appears to me, something more complicated, having a greater number of circles, and in truth what in later times has been understood by the name, Armillary Sphere.

(4.) After COPERNICUS, I find, in a work of APIAN, who was his contemporary, or a little after him, viz. about 1538, a complete description of the *torquetum*, with all the parts of it minutely detailed, assisted by four or five wooden plates, together with the use of the instrument. This work, which is also very scarce, is in folio, intitled, *Introductio geographica* PETRI APIANI *in doctissimas* VERNERI *Annotationes, &c. &c. cui recens jam opera* P. APIANI *accessit Torquetum, Instrumentum pulcherrimum sane et utilissimum. Ingolstadii, anno* 1533. Towards the conclusion of this work is a curious letter of REGIOMONTANUS to Cardinal BESSARION, *De Compositione Meteoroscopii*, that is, the armillary sphere that was used by PTOLEMY, with a plate of it.

(5.) To APIAN succeeded, at some distance, but exceeded all that went before him, the justly celebrated TYCHO BRAHE, who in his *Astronomiæ Instauratæ Mechanica*,* *Noribergæ*, 1602,

* See also *Hist. Cœlestis, Lib. Prolegom.* TYCHONIS BRAHEI, *Augustæ Vindelicorum*, 1666, II. Vol. folio, p. 118 and 119.

folio, has given us a description and wooden plates, of no less than four different astrolabes, under the names of *armillæ zodiacales et equatoriæ*, of different sizes, from $4\frac{1}{2}$ to 10 feet diameter, divided into degrees and minutes, and some of them into every 15 or 10 seconds, but furnished only with plane sights. These large instruments were placed in towers appropriated to each, with moveable roofs, one half of which was taken away at the time of observation. A circumstance that it is curious to remark, is, that TYCHO, who was attentive to every thing that could improve the accuracy of his observations, made the axis of his 10 feet circle hollow, "Axis "ejus è chalybe constans, et undiquâque apprimè teres; in- "terius tamen *cavus*, ne pondere *officiat*, in diametro est "trium digitorum;" a principle that has been very prudently re-adopted in these later times, as will be presently seen.

(6.) After TYCHO I meet with no instrument of this sort till the time of CHRISTOPHER SCHEINER, about the year 1620, who made use of a small telescope, moving upon a polar axis, with an arc of 47° of declination, to observe the sun's disc commodiously, and examine his spots; an account of which will be found in his *Rosa Ursina*, folio, Bracciani, 1630, p. 347. But this instrument can hardly be considered as an astronomical one, being merely a contrivance to follow the sun with a telescope, by means of one motion only, similar in its object with the heliostate, described by Dr. DESAGULIERS, (Mathematical Elements of Natural Philosophy, lib. 5. c. 2.)

(7.) Again, FLAMSTEED'S sector, which he has described in the prolegomena to the third volume of his *Historia Cœlestis*, p. 103, though mounted upon a polar axis, and very ingeniously contrived for the purpose it was intended for, viz.

to measure the angular distances between the stars, having no divided circle at right angles to the polar axis, to take right ascensions, cannot come into the class of equatorial instruments. Nor need I here mention Mr. MOLYNEUX's telescopic dial, (*Sciotbericum telescopicum*, in 1686) though depending upon the principle of a polar axis, which, like a ring dial, or equinoxial dial, was little more than a play-thing for an amateur in astronomy.

(8.) But about the year 1730 or 1735, when the practice of astronomy had assumed a new face in this kingdom, under the skill of Dr. HALLEY and of Dr. BRADLEY, Mr. GRAHAM invented his sector, for taking differences of right ascension and declination out of the meridian; and this may be considered as bearing a considerable affinity to the equatorial instrument in principle, and differing from it only in the extent of its powers. Of this instrument, which is well known to every practised astronomer, a complete account will be found in SMITH's Optics, Vol. II. § 885. and in Mr. VINCE's Astronomy. I approach now to the period when the modern equatorial instrument, properly so called, took its origin.

(9.) Mr. JAMES SHORT, a person of very considerable eminence for his skill in the theory and practice of optics, and particularly for the unexampled excellence to which he had carried catoptric telescopes, in which, I believe, he has never yet been exceeded: Mr. SHORT, I say, probably finding himself capable of making telescopes, of very moderate dimensions, fit for many astronomical purposes, and able to exhibit several of the heavenly bodies by daylight, provided they were furnished with a convenient apparatus and movement for that purpose, applied a two feet reflecting telescope, for

the first time, to a combination of circles, representing the horizon, the meridian, the equator, and moveable horary circle, or circle of declination, each divided into degrees, and every third minute, furnished with levels, &c. for adjustment to the place of observation. This machine was invented in or before the year 1749, and is described in the Philosophical Transactions for that year. But as this instrument was furnished with no counterpoises in any part, and the length of the telescope (two feet) was found considerably too great for circles whose diameter was not more than six inches, it became unsteady, and unfit for any other purpose than that of finding and following a celestial object, and, on account of its high price also, was, as far as I believe, but little made use of.

(10.) However, after some years had elapsed, the idea of an equatorial telescope was again renewed by three several artists in this kingdom, Messrs. RAMSDEN, NAIRNE, and DOLLOND, with many and very material improvements, such as to carry the portable equatorial almost to perfection. Of this instrument Mr. RAMSDEN had made three or four, as early, I believe, as the year 1770 or 1773; viz. one for the late Earl of Bute, one for Mr. M'KENZIE, another for Sir JOSEPH BANKS, and lastly, one for myself; with which I made a great many astronomical and geometrical observations in France and Italy, in the years 1774 and 1775, some of which may be seen in a Memoir upon the Heights of some of the Alps, printed in the Philosophical Transactions for 1777. Of this machine a plate and description in French was printed in the year 1779, and reprinted in English in 1779. An ample account of this equatorial will be found in Mr. VINCE's Treatise on practical Astronomy, p. 159.

In 1771 Mr. NAIRNE published an account of his equatorial telescope, in the Philosophical Transactions for that year; and in 1772 or 1773 Messrs. P. and J. DOLLOND printed an account of theirs. Each of these instruments were furnished with counterpoises, and, in general principles, were at least similar, if not the same. The preference that I was inclined to give at that time to my own instrument, made by Mr. RAMSDEN, was owing to the peculiar advantage of a swinging level, to the unexampled accuracy of its divisions, and its great portability. If, in what I have just now said of the three last instruments, I should have committed any error with respect to the priority of their improvements, I must leave that point to be settled by the artists themselves, and shall hasten to the description of the instrument I set out with. But first one word with respect to an instrument that has been in frequent use on the continent, called, very absurdly, a Parallactic Machine.

(11.) The first notice, that I find of it, is in the History of the Academy of Sciences at Paris, for 1721, p. 18, in a memoir of Mr. CASSINI, with a description and plate of it; also in the History of the same Academy for 1746, p. 121, wherein it is said to have been proposed by Mr. PASSEMENT, but without any description of it; it will, however, be found described, with a plate of it, in the *Dictionnaire de Mathematique, par* Mr. SAVERIEN, two vols. quarto, 1753; and this account has been copied into OWEN's Dictionary of Arts and Sciences, in four vols. octavo. It appears to have been a frame of wood supporting a polar axis, with an equatorial and declination circle, of only a few inches in diameter; and was in fact no more than a very bad stand to a refracting

telescope of 8 or 10 feet long, giving it a motion *parallel* to the equator; and hence some person, not very learned, gave it the name, *Machine parallactique*, as if παραλλακτικὸς and παραλλακτὸς were the same word. It is true that the early astronomers did use a machine called *Regulæ parallacticæ*, but that was an instrument to take the altitudes of the moon, and from thence to determine her parallax. Nor can I say much in favour of a machine of the same name, described in Mr. LA LANDE'S *Astron.* Vol. II. § 2004, which certainly does not do a great deal of credit to the state of the mathematical arts amongst the French; it however may have its convenience, as it is probably attainable at a very small expence. The author last mentioned speaks (§ 2409) of an equatorial in his possession, made by one VAYRINGE in 1787, with circles of 7 or 8 inches diameter, but of what construction we are not informed; and the name of the artist is, I confess, totally new to me. An instrument also of this nature, made by MEGNIE, for the President DE SARON, is described, and seems to be well imagined for a portable machine. This very amiable and ingenious gentleman, Mons. DE SARON, was so obliging, amongst other civilities when I was at Paris in 1775, to shew me a small reflector upon an equatorial stand, with some wheel work to keep it constantly following a star, together with an apparatus for the refraction, altitude, and azimuth, if I recollect right; and in the year 1778 Mr. WILLIAM RUSSEL, a late worthy member of the Royal Society, shewed me a small instrument of the same kind, that had been made by the late Mr. BIRD.

(12.) From the preceding account, it must appear that the equatorial instruments hitherto made, either from the small-

ness of their dimensions, or defect of their constructions, were totally unfit for the accuracy of modern astronomy, where an error of a few seconds only, in an observation, is all that can be admitted, to entitle it to any credit.* With respect to the precision of astronomical instruments in general, I may notice by the way, that from the time of HIPPARCHUS and PTOLEMY, before and at the commencement of the Christian æra, to the age of WALTHER and COPERNICUS, in the beginning of the 16th century, few observations can be depended on to within less than 5, 8, or perhaps even 10 minutes; those of TYCHO BRAHE, indeed, that princely promoter of astronomy, to within one minute. The errors of HEVELIUS's large sextant of 6 feet radius, towards the middle of the last century, might amount to 15 or 20 seconds. FLAMSTEED's sextant to 10 or 12 seconds; and lastly, those of Mr. GRAHAM's mural quadrant of 8 feet radius, with which Dr. BRADLEY made so many observations from 1742, might amount to 7 or 8 seconds.

(19.) Having said thus much generally upon the subject of this ingenious instrument, and not more, I trust, than will be deemed, by every lover of this science, what its importance deserves, I proceed to the description of one I have caused to be made by a very able artist of this metropolis, Mr. JESSE RAMSDEN.

AB, CD, EF, GH, (Tab. IX.) are 4 columns composed of hollow brass tubes $8\frac{1}{2}$ inches in diameter, and 5 feet 10 inches long; these, with two others, one of which appears

* I must except from this remark the two large equatorial sectors made by Mr. SISSON, for Greenwich observatory; and also an instrument of this kind, made by Mr. RAMSDEN, for the late General ROY, and now in the possession of Mr. AUBERT, whose circles are about 30 inches in diameter.

in part at IK, and the other wholly hid behind EF, are firmly fixed, at their upper ends, to a circle of bell metal, BDFH, and, at their lower end, to an inverted truncated hollow cone* LLL, of brass, in height 2 feet, and in diameter at its base AG, 1 foot 9 inches. The cross pieces or tubes P,P, as likewise O,O, and O,O, serve to connect the columns more strongly together, and prevent their bending. These several parts constitute the principal axis of the instrument, the lower end of which terminates in a steel point or cone, resting in a hollow conoid of bell metal, in such manner that the apex of the former does not reach to the bottom of the latter, but the place of bearing, and of friction, is (it may be) about two-tenths of an inch from the extremity of the cone; the other end of this axis finishes in a cylindrical pivot N, of about 1¼ inch long, and 1 inch in diameter, turning in a Y of bell metal. The entire length of this axis is 8 feet 4 inches, the lower end being supported by an iron frame 3, 4, 5, 6, 7, 8, which is firmly fixed, below the floor, into brick work, and, by means of two iron bars, one of which is seen at 28, and the other on the opposite side, not visible in the drawing, is kept secure from any motion eastward or westward; the lower part of this frame, to about one foot high, is inclosed by a mahogany box, or case, 9, 10, the top of which is intirely covered up, and serves as a die or base to this end of the instrument. The other extremity of this long

* Upon this cone are inscribed the following words.—"Hocce Panorganon Uranometricum à JESSE RAMSDEN, Londinensi Optico celeberrimo, et omnibus id "genus artificum longe anteponendo, excogitatum, decem post annos nunc tandem "absolutum, GEORGIUS SHUCKBURGH Baronettus, in testimonium amoris sui erga "res astronomicas, et ad easdem promovendas, fieri curavit, anno 1791."

axis, viz. the pivot N, rests upon the strong iron support 29, 30, 31, standing ten feet above the floor, made of massive pieces of cast iron, 2½ inches wide, and ½ inch thick, and held firmly together by bolts and nuts, as in the figure. 32, and 33, are two iron bars nearly at right angles to each other, and at ½ right angles to the meridian, that connect this upright support with the walls of the building, and, going through the bricks, are held fast by iron collars and nuts on the outside of the wall; these bars or braces resist any tendency, from the weight or pressure of the instrument, to push the supporter 29, 30, and 31, out of its upright position; and, being at right angles to each other, serve to keep it steady with respect to any lateral force that may accidentally be applied. The lower part is continued below the floor, and firmly fixed, with mortar and lead, into the brick work of the arch which will be presently described. The bottom is shut up in a box or plinth of mahogany, 34, 35, as has been mentioned in the description of the frame supporting the other end of the axis, at 9, 10. Near the lower end of the principal axis LN, are inserted 10 concentric brass cones or radii, *aa*, *bb*, *cc*, *dd*, *ee*, carrying on their extremities a graduated brass circle, of 4 feet diameter,* at right angles to the principal axis already described; this circle has two sets of divisions, one of points, and one of lines, each into degrees, and every 10 minutes, and the intermediate minutes and seconds are read off by the microscopes W and X, with a moveable wire and micrometer screw, such as has been described in General Roy's Account of his Instrument for measuring horizontal Angles. (See Philosophical Transactions, Vol. LXXX. p. 145.). The circle just

* More correctly 49½ inches.

mentioned is inclosed by a circular frame, or rail of mahogany, 14, 15, which is supported by ten balusters, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, and serves to protect the brass circle from any accidental injury in passing by it, without depriving it of exposure to the general temperature of the room. It, at the same time, affords means of support to a small lamp, 13, which, by reflection from the perforated speculum at the bottom of the microscopes, to be seen in that marked X, throws light upon the divisions by night. 26, 26, and 27, are iron rods, that, by being attached to the wooden case, 9, 10, give steadiness to the upright balusters, and the circular frame that they support. 1, and 2, are large stout brass cones, firmly fixed into the frame 3, 4, 5, 6, 7, 8, before mentioned, and whose use is to carry the microscopes W, X; any degree of pliancy or flexure in these cones would be readily discernible in the microscopes, and extremely detrimental to the observations, they are therefore made as stiff as possible. 7, 8, is a plane forming the upper side of the frame 3, 4, 5, 6, &c. and consisting of 3 plates, two moveable in grooves, and one fixed, furnished with suitable screws, one giving the extremity of the axis a motion upward or downward, and the other a motion to the right or left: this latter is procured by a rod passing through the cone 2, one end screwing into the plate below L, near the centre, and the other turned by an occasional handle fixed on near X; the former motion, viz. of elevating or depressing the axis, is procured by a handle fixed on to a screw near 8. QR is another circle, of the same dimensions with the former, graduated in the same manner, and held together by eight conical radii, firmly screwed to a circular centre piece, which serves as a base to a large conical axis, 2 feet 3 inches long,

one side of which is seen at U, and its exterior extremity near V, with its sliding plate and screws for adjustment. Close behind the graduated circle, and at right angles to this axis, passing through it, lies the telescope TS, 5½ feet long. This circle is likewise furnished with two microscopes, and micrometers, as in the equatorial circle, one of which is seen at full length at Y and Z, the eye tube being at Y, and the object glass, with the perforated speculum to throw light, at Z; the other microscope, on the opposite side of the circle, is not so discernible in the drawing, being completely foreshortened at Z near T, the eye of the draftsman having been exactly in the axis of the tube of the microscope. $\alpha, \alpha, \alpha, \alpha, \alpha, \alpha,$ is an hexagonal lozenge, composed of six brass rulers, firmly fixed to the columns AB and EF, and supporting the lower end of the microscopes, as the pieces $\beta\beta, \beta\beta,$ in like manner, sustain the upper end. By these means the wire in the field of the microscopes becomes a fixed immoveable index, and, after proper adjustment, an exact diameter of the circle, whilst the telescope, together with the circle, turns round the conical axis before mentioned. At P is a spirit level, passing through the centre plate of the conical axis at right angles to the telescope, supported by a cock at each end, one of which appears at *k*; this cock is fixed to the cone U, and, by means of a small toothed wheel and pinion, the level is made to revolve round its own axis, so that the same side of the level may readily be brought uppermost, whatever position the circle be put into; it is also furnished with all necessary adjusting screws. It will readily be seen that a telescope, thus fitted up, will have all the properties of a transit instrument,

while the graduated circle will possess those of a meridian quadrant. For this purpose *l*, *m*, is a stout brass tube, inclosing a stiff iron rod, turning upon two fine steel points, adjusted, by proper screws, parallel to the line of sight of the telescope; this rod is attached to a spirit level of great sensibility, lying below it, which, with the rod, turns round upon the steel points just mentioned, and is in fact a hanging level of the best construction. At the eye end of the telescope S, is a peculiar apparatus to correct the effects of refraction and parallax, when an observation is made out of the meridian: it is composed of two levels, a small quadrant of altitude *n*, *o*, and a semicircle divided, with its nonius, to every 5', on the breech plate of the telescope, the exterior eye tube having a circular motion, by a wheel and pinion at *o*, independent of the tube that carries the cross wires; by this means, the angle of the horary and vertical circles may at any time be found, together with the altitude of the object, and then, by the resolution of two right angled triangles, the refraction and parallax, in right ascension and declination, will be obtained. *t*, *u*, are two handles to a HOOK's joint at *x*, *x*, which, turning an endless screw at *w*, *w*, give a gradual motion to the telescope in right ascension or declination; and this motion can at any time be restrained by a clamp at *q*. The handles *t*, *u*, are hung on to any part of the instrument, by means of the line and wire *v*, *v*, and are thus kept within the observer's reach. *r* and *s* are two microscopes, placed on opposite sides of the circle QR, and at right angles to the line of sight of the telescope, of use only when the plumb line is used in preference to the level *l*, *m*, above described,

either for adjusting the instrument, or observing a meridian altitude. *y* and *z* are thin perforated brass plates, attached to the cover that goes on the object glass, and, by occasionally turning them over it, change the aperture to $\frac{1}{2}$ or $\frac{1}{4}$. The cross wires, of which there are 3 vertical, and 1 horizontal, within the eye tube S, have all the requisite adjustments by screws, &c. as in a common transit instrument, and are enlightened by night, by a lamp fixed near to one end of the declination axis U, viz. that opposite the end V; but this part of the apparatus is hid behind the axis and the telescope, except the weight *i*, which is a counterpoise. This lamp throws a light through the conical axis, which is perforated at that end on purpose, on a speculum in the centre of the telescope, placed at $\frac{1}{2}$ right angles to the axis of the object glass, and from thence reflected to the cross wires. This speculum, which is an elliptical diaphragm, is perforated to permit all the rays from the object glass to pass unobstructed to the eye. This contrivance has been mentioned by Mr. VINCE. (Practical Astronomy, p. 80.) From what has been already described, it must now be evident that if the principal, or polar axis, as it has been called, LN, be elevated to the latitude, and adjusted to the meridian of the place, if the line of sight of the telescope be at right angles to the axis VU, and this latter at right angles to the polar axis LN, the brass circle 14 and 15 will correspond with the equator in the heavens, and the circle QR will become an horary circle; viz. that if the centre of the wires, in the field of the telescope, be directed to any celestial object, on QR will be had its declination, and on 14 and 15 its distance from the meridian, from whence, by knowing the hour, the right ascension

will be obtained,* and consequently its true place in the heavens.

(14.) Before I proceed, it may be necessary to say something of the remaining parts of this apparatus, such as are either necessary to it, or concomitant in the use of it. These are, 1. The lamp to illuminate the cross wires. 2. The refraction piece. 3. The plumb line. 4. The moveable roof. 5. The regulator. 6. The meridian mark. And these will be best understood by inspection of the plates, where Tab. X. figure 1, represents the lamp fixed to the farther end of the declination axis. AB is the brass case or lantern, suspended on two centres C and D, within the frame E and F, which is attached to the pillars of the equatorial (IK, GH, and that one hidden behind EF) by the cylindrical braces *a*, *b*, *c*, *d*. *e* is the lamp or vessel containing the oil, swinging upon the centres *f* and *g*, at right angles to C and D; and by means of this cross axis, and the counterpoise *b*, the lamp is kept constantly in an upright position, whatever may be the situation of the declination axis. G is a chimney to carry off the smoke from the instrument, and prevent its heating it. *i*, is a convex lens, that collects the rays from the flame upon the extremity of the declination axis, U, V, which, being hollow, conveys *all* the light to the perforated speculum before mentioned, within the centre of the axis and of the telescope; and this is assisted by another convex lens at the end of the axis, before which occasionally is screwed a pale green glass, of which there are three, of different shades, to temper the light of the lamp, if necessary, to the light of the

* The adjustments which I have just now mentioned, together with some others, will be duly explained in their proper places.

star that is to be observed. This light, as was said before, being reflected down the tube to the wires, the stars are seen upon a beautiful pale green field, the wires appearing black. The centre D being of necessity full two inches in diameter, in order to admit of the aperture and lens *i*, rests on three friction wheels, and by this means the motion is as easy as on the centre C. At *k*, *l*, *m*, *n*, is a small sliding door, to close up the lantern from the wind, but which is here removed to shew the inside.

(15.) Tab. X. figure 2, represents the refraction piece. AB is a portion of the telescope; C the eye tube; *a*, *b*, *c*, a divided semicircle; *d* its nonius fixed to AB, shewing the angle of the horary and verticle circles; *e*, a small spirit level, attached to the plate on which this semicircle is engraved, and moving with it by means of the screw *f*, which turns a pinion, that works in a toothed wheel, that turns the whole plate, together with the exterior eye tube, round its centre, but without moving the tube that carries the cross wires. From hence it may be understood, that by turning the screw *f*, till the level *e* stands true, the index *d*, which represents a point in the horary circle, will mark how much the division zero, (*o*) which represents the vertical, is inclined thereto. *l*, *k*, is a small quadrant of altitude, that, by means of the level *g*, and screw and pinion *b*, turning on a centre at *m*, gives the elevation above the horizon of any object in the field of the telescope. *i*, is a small aperture through which a key is fixed on, to give a lateral motion to the wires to adjust them; and near *f* is another screw, to adjust them parallel to the equator and declination circle.

(16.) Tab. X. figure 3, represents the plumb line and its frame; it is about 5 feet long, and suspended to the roof of the observatory by the two hooks *a*, *a*. AB is a hollow brass tube, to protect the plumb line from the wind; the line or wire is fixed at the top near *b*, and sustains the plummet in a glass of water at C. *b* and *c*, are two adjusting screws, moving a sliding plate at right angular directions, to which is fixed the upper end of the plumb line. *d* is a screw, that by means of a pinion moves a rack *e*, *e*, to depress or raise the glass of water, and thereby support the plummet, (when this apparatus is moved about from one side of the instrument to the other) and prevent the wire being broken, and, by depressing it, to enable the plummet to play free, when it is to be used. At A and B are two apertures, at 4 feet distance, corresponding with the two microscopes, covered on the back-side by pieces of transparent ivory, in order to exhibit an agreeable field of view, to observe the coincidence of the plumb line with the cross wires in the microscopes.

(17.) In Tab. XI. is seen a section of the building in which this instrument is placed. As the equatorial is a machine calculated to observe the heavenly bodies in every part of the hemisphere, so it became necessary to construct a chamber, with windows opening to every quarter, north, east, west, and south; and to any degree of elevation above the horizon. With this view I erected a building, or small turret, within my house, at Shuckburgh, in Warwickshire, see Tab. XI. where *a*, *b*, *c*, *d*, represent a section of this room, being about $15\frac{1}{2}$ feet square, containing the equatorial AB, resting on its supporters CD. *s*, *o*, *p*, *r*, *q*, *t*, is a hollow conical

roof,* moveable round its axis upon six friction rollers, of about 4 inches in diameter, two of which are seen at *s* and *t*. The base of this cone consists of an iron ring, about 11 feet in diameter, and 3 inches wide; the upper part of the cone at *s*, is terminated by another iron ring $2\frac{1}{2}$ feet diameter; and these are connected by 12 iron ribs, or rafters, in the direction of *s*, *s*. Over these rafters lie two coats of extremely thin deal planks, not more than $\frac{1}{8}$ inch in thickness each, crossing each other in transverse directions of the grain of the wood, and over these a covering of copper, of about the thickness of a shilling. Over the copper, on the outside, are three good coats of white paint, and the wood withinside is lined with stout canvas, well painted also; so that the whole roof is as moveable and as light as possible, not more than 200 or 300lb. weight, and withal very strong. At *s* and *s*, is an aperture in the roof, of about one foot wide, which is opened or covered, suitably to the occasion, by the two doors *o*, *p*. *r* is another door, (in the plate) open; by means of these three doors, all opened very readily by iron rods withinside, a prospect is given of the heavens from the horizon to the zenith, and even to 10° beyond it. *q* is another aperture, about 9 inches long and 4 wide, covered occasionally by a shutter *z*.

* As I flatter myself that I have now executed what the very celebrated Abbé Boscovich seems to have had in view, in the 14th opusculum of his fourth volume of *Opera pertinentia ad Astronomiam, &c.* I cannot restrain myself from citing the passage, wherein, after describing the use of the *small* equatorial, he says; "Apparet "igitur egregius usus machinæ etiam *mobilis*. Verum machina parallactica metallica "cum circulo, et semicirculo, satis magnis, ac telescopio acromatico, et satis bono mi- "crometro filari, collocata firmiter in turri habente tectum mobile, esset instrumentum "usus immensi et expeditissimi, ac incredibilis ad astronomiam cum maximo fructu "excolendam utilitatis." p. 309.

This little window affords a constant view of the pole star in its whole revolution, if the sky be clear, and consequently an opportunity of comparing a transit and altitude of any star to the southward directly with it; and, by moving the conical roof round, any part of the sky may be exposed to the telescope. The rollers* *s*, *t*, roll upon a surface of lead, melted and cast into a circular groove in the timbers at EE, and planed truly horizontal. Besides the apertures already described in the roof, the room is enlightened by two windows to the south-east, and north-west; and also by two oval lights in the side of the cone, nearly east and west, and by a third in the zenith at *r*. *v*, *w*, is a platform on the outside of the cone, covered with lead; of use in examining the roof, and cleansing it in time of snow, &c. *y* and *x* are iron balusters, very necessary on such occasions, with the iron rail at top at *x* placed obliquely, in a plane tending to the centre of the instrument, in order that the least possible light from any object may at any time be lost to the object glass. C is one of the iron bars passing through the wall of the building, fixed by a collar and nut on the outside, and resisting the pressure of the instrument, whose weight, without the supporters, is full 3001b. against the support D. *e*, *f*, *l*, and *g*, *b*, *n*, are two of the side walls of the building, rising 40 feet above the ground, and serving as *butments* to the arch *l*, *m*, *n*, which is farther strengthened by a square frame, of heart of oak timber, 9 inches by 6 inches, let into the wall at *5*, *6*, held together by iron bolts, and going round the building.

* Besides these rollers, whose axes are horizontal, there are 3 or 4 other rollers, upon a vertical axis, exterior to, and bearing against the ring that constitutes the base of the cone; by this means they keep the centre of its motion always in the same place.

This arch is filled with solid masonry * to the height *i*, *k*, into which, as upon a plane brick floor, the iron frames that support the instrument are firmly fixed with plaster and lead at 1, 2, and 3, 4, and hence the instrument seems as steady as upon a rock. *b*, *d*, is a boarded floor, that has no connection whatever with the instrument, or its supporters. *u*, *u*, are the two mahogany cases that cover up the apertures in the floor, and serve as bases to the supporters C and D, but do not touch the iron frames within $\frac{1}{4}$ inch; so that any yielding of the floor, *b*, *d*, by passing to and fro thereon, communicates no motion whatever to the instrument.

(18.) To the north-east wall† *c*, *d*, by means of timber laid into it, and long screws, is firmly fixed the clock, or sidereal regulator, but so as to have no communication with the floor. As it is peculiar in its construction, it may deserve some notice. Whereas most astronomical clocks shew sidereal time in hours and minutes, which is afterwards, in the course of computation, reduced to degrees and minutes; this machine shews the degree and minute of the equator, that is upon the meridian at any given instant, directly without reduction. This is of considerable convenience in observations, out of the meridian, with an equatorial instrument; inasmuch as the equatorial circle and the clock, by these means, speak the

* The bricks of this arch were laid dry, and then grout, consisting of gravel and hot lime, was poured upon them; when the arch had stood two years, the haunches were filled up with bricks, laid in mortar. I mention these circumstances, as attention to them may be of use upon a similar occasion, whenever it shall be necessary to erect an arch bearing so great a weight, viz. near 30 tons, upon such slight buttresses.

† The walls of this room do not correspond with the cardinal points; the section here given having an aspect 53° S. east.

same language. For this purpose the vibrations of the pendulum are only $\frac{1}{3}$ of a common pendulum, $= 10''$ of space; and the index that is carried round immediately by the pendulum, viz. on the same arbor with the pallet wheel, in one revolution describes $10'$ of sidereal space; the next index from the centre of the dial plate shews the degrees, and every 10th minute, making one revolution in 10°. And lastly, the decades of degrees, from 1 to 36, $= 360°$, are shewn through an opening in the dial plate, which in some clocks is appropriated to the day of the month. But perhaps this will be better seen from inspection of the plate (Tab. XII.) wherein the hands are so placed as to indicate $147° 14' 10''$. The small hand (it may be perceived) has two sets of figures round its circle, the one shewing the minutes, and every 10th second, the other the number of beats from 0 to 60, and this latter enumeration is what alone can be attended to in the observations; that is, the degrees and every 10th minute are set down in the journal immediately from the indexes, and the subdivisions below $10'$ are set down in beats of the pendulum, reckoning from 0 to 60, and reduced afterwards at leisure. The pendulum, only 17 inches $\frac{4}{10}$ in length, is a compound gridiron composed of 5 rods, of which 3, viz. the centre and two exterior, are of iron, and the two next to, and on each side of the centre, are compounded of silver, brass, and zinc. The weight of the pendulum ball is about 6 pounds, and that of the clock weight 32. The spring, by which the pendulum is suspended, is said to be so constructed as to produce cycloidical arcs of vibration; but my reliance upon this contrivance is not very perfect. The two chief arbors are jewelled, the pallets are rubies, and the axis of the principal

great wheel moves on friction wheels; and I believe every care has been taken, that the experience of one of the first artists of this kingdom * could suggest, to render it a complete piece of mechanism. It goes five months with once winding up; and, from the experience I have hitherto had, does not seem to vary its rate between winter and summer more than equal to three seconds *per* day, sidereal time.

(19.) All, I believe, that remains for me to mention, in this part of the account, is the meridian mark. (See Tab. XIII.) A, B, C, D, E, is a solid brick pier, erected at the distance of 2970 feet from the centre of the observatory; 8 feet high, 9 feet wide at bottom from A to E, and 4 feet wide at top from B to C; 1 foot 6 inches thick at top from C to D, and 2 feet 3 inches at bottom. F is an iron box, 8 inches square, and 1 foot high, exclusive of the top, or chimney; within this box is placed one of ARGAND's patent lamps, which shines through a circular aperture, of about $1\frac{1}{4}$ inch, in the front of the box, and exhibits the appearance of a fixed star to the naked eye by night; but the aperture being covered by a semitransparent piece of glass, ground rough on one side, transmits a steady uniform light, that through the telescope resembles the disc of a small planet $7''\frac{1}{2}$ in diameter. By making the wire in the telescope, which is only $2''\frac{1}{2}$ in diameter, bisect this circular light, the instrument may be very nicely adjusted to the meridian, indeed with so great precision, that I think an error of one second cannot be committed. Around this glass aperture, which by day appears perfectly black, is painted a circle of black, (on a ground of white) whose external diameter is 3 inches, and

* Mr. JOHN ARNOLD.

consequently subtends an angle of 18″. The bisection of this last is made use of by day, and although, it is true, it is rather larger than is necessary for a meridian *point*, yet it was convenient it should be so, to render it visible in the dark winter months, if there was the least vapour rising from the ground. Yet with all this, no error need be apprehended exceeding 2″, equal to only $\frac{1}{9}$ of a second of time, nor that, unless the image should be greatly agitated by the vapours. This mark is not only of use to find the meridian, but also to determine the horizontal point, when once the angle of it above or below the horizon is ascertained; and, by comparing the meridian altitude of any object with this point, its declination may be had, almost as nearly as by the level or plumb line.

I ought to have mentioned before, that the box F is moveable upon the plane B, C, by means of an iron frame on which it slides, and screws to adjust it finally to the true meridian.

Although there can be no great danger of a solid pier, like the above, erected on a foundation four feet deep, being likely to move, yet this doubt, if any should occur, may be examined by a plumb line *a*, *b*, suspended from *a*, and playing near a corresponding mark, on the top of a post driven into the ground at *c*. G, E, are steps to ascend to light the lamp, or take it in and out at the door *d*. The whole is surrounded by high pallisadoes, to protect it from the accidents of cattle, or curiosity.

(20.) Having thus particularly described the various parts of the equatorial, I trust in a manner sufficiently intelligible to any person a little conversant with astronomical instruments, it may be proper to say something of its precision;

for without some competent knowledge of the accuracy of its parts, it is in vain to attempt to adjust them, and still more so to use them with any degree of satisfaction. And here the chief objects of inquiry have been the accuracy of the divisions; the sensibility of the levels; and the power of the telescope. I shall begin with the levels; and first with the axis level, P, *k*, the parts of which may be seen at figure 1, Tab. XIV. where 1, 2, represent the extremities of the axis of the circle of declination; A, a section of the tube of the telescope; 3, 3, the level tube, resting in the cocks or supporters, 4, 4, and 5, 5, and turning on an axis *d*, *e*; on one end of which *e*, is a toothed wheel *g*, moved by a small pinion *f*, turned by the screw head *b*; and at *a*, is an adjusting screw to bring the level parallel to the axis 1, 2; at *c* is another, to bring the level parallel to its moveable axis *d*, *e*; *b*, is an adjusting screw, at right angles to C, to bring the tube of the level parallel to its axis *d*, *e*; *i*, is another screw, to make this axis parallel to the axis 1, 2. All these, as well as every other adjusting screw throughout the instrument, have chamfered heads, with their circumferences divided into 10 parts, and the value of each ascertained; so that, by turning the screws a whole, or any part of a revolution, the angle of motion given to any part may be known. The use of this is obvious; but the degree of convenience is only known to such persons as have been conversant with these nice adjustments. *k* and *l*, are two moveable indexes, to be set to each end of the bubble. The tube of this level is about 14 inches long, and the curvature of it such, as that by giving it an inclination of 15″, the bubble moves about $\frac{1}{10}$ inch, and the third or fourth part of this space is plainly discernible, so that no

error exceeding 3 or 4″ need be apprehended, if proper care is taken.

The swinging level *l*, *m*, fixed to the tube of the telescope, for the purpose of taking declinations, is unground, and of very superior sensibility, as it ought, having been selected expressly from a great many yards of glass tube, in order to get one with a proper flexure; and such has been the success of this care, that a change of inclination of this level of one single second, moves the bubble nearly $\frac{1}{2}$ of an inch, certainly more than $\frac{1}{10}$.* This, I am inclined to believe, is the greatest sensibility that has ever yet been attained by a level: it is at the same time somewhat inconvenient, since it sometimes will require two or three minutes time to settle to its true point, it moves so slow. An error, however, of more than a second need seldom be apprehended, which I conceive is as much as could have been expected from a plumb line of a length equal to the diameter of the circle. The bubble of this level is about 7 inches long, but this varies with the temperature; and I have experienced that with about 28° of heat the bubble contracts one inch in length; this makes it very necessary to be attentive to the index at each end of the bubble. The parts of this level may be seen at figure 2, Tab. XIV. A, B, is one side of the tube of the telescope, whereon are firmly fixed two upright supporters, or cocks, C, D, and E, F;

* If the motion of the bubble be taken to be even 0,2 inch, it will be found that the radius of curvature is more than 1100 yards; and, supposing the length of the level = 12 inches, it will only comprise, from one end to the other, an arch of 1′, and the versed sine of 30″, in this case, would express the depressure of the tube at its extremities below the centre of the level = about half $\frac{1}{1000}$ of an inch.

The curious ground level, for adjusting the axis of the transit instrument at the observatory at Greenwich, moves, as I have been informed, about $\frac{1}{10}$ inch for 1″.

in which the level G, H, I, about 12 inches long, swings upon two conical centres *a*, *i*, truly turned, of polished steel. G I, is an hollow brass tube, about $\frac{1}{2}$ inch in diameter, containing within it a steel triangular axis, one extremity of which is terminated by the conical centre *a*, and, by means of a spiral spring winding round the axis, is made to contract its length by pulling the trigger *g*, towards I, by which means the point or centre *a*, retires within the tube G I; so that the two centres may easily be released from the steel pivots wherein they play, and the level may be reversed, if necessary, to adjust it. It is evident that the axis *a*, *i*, should be parallel to the line *b*, *b*, which may be taken for a tangent to the curvature of the tube at *k*, and this is procured by the capstan headed screw *c*; it is also necessary that this same axis should be parallel to the line A B, or rather to the line of collimation of the telescope, in a north and south direction, and this is obtained by the capstan screw *d*. Finally, it is expedient that this axis be parallel to the line of collimation, in a direction east and west; and this is effected by the screw *b*. *e*, *e*, are two indexes to mark each end of the bubble, and, being fixed to the two concentric sliders *f*, *f*, which embrace $\frac{3}{5}$ of the circumference of the tube G I, are moveable any where at pleasure. *b* is one of two screws, the other being opposite and out of sight, for adjusting the axis *a*, *i*, parallel to the line of collimation, eastward or westward, as has been said, and at right angles to the declination axis. I proceed next to the divisions.

(21.) The superior advantages of an entire circle,* over a

* Vide *Observationes Astronomicæ Annis* 1781, 1782, 1783, *institutæ in Observatorio Regio Hauniensi*, auctore THOMA BUGGE, Hauniæ, 1784. Quarto. Cap. 5.

quadrant or sextant, for astronomical purposes, are almost incredible to a person that has not considered the properties of a circle, and so great, that I am much surprised it has not been brought into more frequent and earlier use. For, in the *first* place, the error of the centre, which so constantly takes place in quadrants, is entirely done away; *secondly*, the small error in each individual division is discovered, so that whatever be the skill of the artist, the observer is under no obligation to rely upon it, but can examine the whole himself. The method I proposed was this, to make the index wires in the opposite micrometers an exact diameter to the circle, and then to observe whether each division corresponded with its opposite one, and if any difference, to set it down; these differences I expected to find somewhere = 0″.0, viz. in the diameter passing through the true centre of the circle, and the centre of the pivot, round which the machine revolved, and at right angles to this they would be at a maximum. The greatest quantity of this eccentricity, and the place where it lay, being ascertained, it would be easy to determine what it was in any other place; for this eccentricity, in any given part of the circle, would be as the co-sine of the distance from that point where it was at a maximum; and if, on this principle, a table was constructed, giving the eccentricity at every degree round the circle, the numbers in this table might be compared with the actual observation of the eccentricity, by the microscopes all round the circle, and if the quantity in the table did not every where agree with that found by experiment, the difference would be the actual error of that individual division; and in this manner the whole might be examined, every error detected, and a memoran-

dum made of it. With this intention, and a full expectation of finding the eccentricity = 8″ or 10″, I set to work to examine the circle all round, having previously determined the diameter of the points in the arch to be about 21″, and the thickness of the wire = 12″. It is true, the points were not all exactly of the same size, nor could it be expected, but in general it might be concluded, that when the wire equally bisects a point, the segment on each side of the wire is about = 4″: so that an error of 1″ in the bisection can never be committed, with a tolerable light and reasonable care, the microscope magnifying 16 or 18 times. I placed the moveable wire of the east microscope so as to bisect the division 360°, and then, by repeated trials, made the moveable wire of the west microscope bisect the opposite point of 180°; in which, taking a mean of three or four observations, I could not err more than a few tenths of a second. The index of the micrometer screw being then carefully adjusted to zero (0) of the divisions of the head, I made every 10th degree of the circle pass under the micrometer wire of the east microscope, which wire might now be considered as fixed, and then noted whether the opposite division was under the moveable wire of the west microscope; if not, I wrote down the difference, after three or four times reading off. The result of these experiments may be seen in the adjoined table. Where

The 1st column shews the point, or division, that was brought under the wire of the east microscope.

The 2d column shews the want of coincidence, or how much the opposite point disagreed with the wire in the opposite microscope, at each reading off.

The 3d column gives the mean difference, and is = double

the error of the centre + the sum of the errors of the two divisions.

The 4th column shews the difference of the mean reading off from the extremes, and may be considered as the greatest actual error in reading off these observations.

The 5th column contains the numbers in the 3d column corrected, by subducting 0″.9, a quantity which, it was found, upon taking the mean of all the numbers in the 3d column, the opposite or west micrometer was too forward upon the circle, viz. did not make a perfect diameter, but exceeded it in the order of the degrees by 0″.9. It will be observed that this quantity, from the three first series of observations of the points 360, and 180°, seemed to amount to 0″.6; this difference is inconsiderable. The numbers then in the 5th column, thus corrected, will express the true difference between the opposite divisions, if the wires in the microscopes had described a true diameter.

The 6th column gives the half of the difference just mentioned, and is = the simple error of the divisions.

Table of the Divisions of the Equatorial Circle.

1	2	3	4	5	6	1	2	3	4	5	6
East microscope.	West microscope, and difference.	Mean difference.	Difference of the mean from the extremes	Column 3d corrected.	Simple error.	East microscope.	West microscope, and difference.	Mean difference.	Difference of the mean from the extremes	Column 3d corrected.	Simple error.
° ′	°	″	″	″	″	° ′	°	″	″	″	″
360 0	180.					80 0	260.				
	″						+ 3,4	+ 3,6	0,2	+ 2,7	+ 1,35
	+ 0,0						3,5				
	1,2	+ 0,7	0,5	− 0,2	− 0,1		3,8				
	0,7					90 0	270.				
	1,0						+ 0,8	+ 1,1	0,6	+ 0,2	+ 0,1
	0,6						0,8				
360° 0′	+ 0,4						1,7				
repeated	0,8	+ 0,7	0,2	− 0,2	− 0,1	100 0	280.				
	0,9						+ 1,5	+ 2,0	0,5	+ 1,1	+ 0,55
360° 0′	+ 0,8						2,2				
repeated	0,2						2,4				
	0,0	+ 0,4	0,4	− 0,5	− 0,25	110	290.°				
	0,5						+ 0,7	− 0,7	1,0	+ 1,6	+ 0,8
mean of these three		+ 0,6					− 1,2				
° ′	°						− 1,7				
10 0	190.					111	291.				
	″						+ 0,8	+ 0,9	0,6	+ 0,0	0,0
	+ 1,5	+ 2,3	0,8	+ 1,4	+ 0,7		1,5				
	2,6						0,4				
	2,7					120	300.				
20 0	200.						− 0,5	− 0,2	0,5	− 1,1	− 0,55
	+ 1,0						− 0,7				
	0,7	+ 0,9	0,2	0,0	0,0		+ 0,5				
	1,0					130	310.				
30 0	210.						+ 0,7	− 0,3	1,0	− 1,2	− 0,6
	+ 3,1						− 0,5				
	4,1	+ 3,8	0,7	+ 2,9	+ 1,45		− 1,0				
	4,0					140	320.				
	3,9						− 2,7	− 2,2	0,6	− 3,1	− 1,55
40 0	220.						− 1,6				
	+ 4,2						− 2,3				
	3,9	+ 4,1	0,2	+ 3,2	+ 1,6	150°	330.				
	4,2						− 0,4	+ 0,4	0,8	− 0,5	− 0,25
30 0	230.						+ 0,7				
	+ 1,6						+ 1,0				
	1,5	+ 1,5	0,1	+ 0,6	+ 0,3	160	340.				
	1,5						− 2,2	− 1,8	0,4	− 2,7	− 1,35
40 0	240.						− 1,2				
	+ 2,8						− 2,0				
	3,6	+ 3,4	0,6	+ 2,5	+ 1,25	170	350.				
	3,6						− 1,6	− 1,8	0,4	− 2,7	− 1,35
70 0	250.°						− 2,2				
	+ 3,2						− 1,7				
	3,0	+ 2,7	0,7	+ 1,8	+ 0,9						
	2,0						Mean of all	− 0,9	0,53		

Those with ° affixed are doubtful or bad points.

From inspection of the preceding table of observations it will readily appear, that I was much mistaken in my expectation of an eccentricity of 8 or 10″, for that, in truth, there seemed to be no fixed cause of error; and that therefore the error of the centre had little to do in occasioning those differences in the opposite microscopes, which only once amounted to 4″, and this in fact was double the error of the centre added to the sum of the errors in the two opposite divisions, together with the error of twice reading off; and that the simple error never exceeded, and but once amounted to 1″,6. This being the case, I think it fair to conclude, that the eccentricity never amounted to any sensible or measurable quantity, viz. never exceeded 1″,* and that consequently all the variety we see, in the west or opposite microscope, arose from the error of the divisions, inequality of the points, imperfection in reading off, or a little play in the screw of the micrometer. But, as all these together never but once amounted to 2″, I think it may fairly be presumed that *that* is the *greatest* error that will arise, in any observation made with this circle, when only one microscope is used, and that probably only half that error will take place.

* How extremely small a quantity this is, may be seen by considering that, on a radius of two feet, an arc

of 10′ amounts only to	- - - - -	0,0698 inch.
of 1′ ———	- - - - -	0,0070
of 1″ to (= in round numbers to about $\frac{1}{1800}$ inch.)		0,000116

Viz. to about 8 times less than the *minimum visibile* to the naked eye. This I reckon, with my own eye, at $8\frac{1}{2}$ inches distance, is about $\frac{1}{1600}$ inch; but then it must be considered that the microscopes magnify 16 times, and will therefore render a space visible that is $\frac{1}{12800}$ inch, or about = $0''{,}5$, which we shall soon find to be the fact.

After this examination of the equatorial circle at every 10°, I did not think it necessary to proceed in the examination of each degree, and still less of every 10′, as I had intended. I therefore quitted this, and went to the declination circle, which underwent the same trial. The results of which will be seen in the adjoined table; the divided arch of the declination circle being turned towards the east.

Table of Observations of the Divisions of the Declination Circle.

1st microscope next the eye.	Farthest microscope next the object glass.	Mean difference.	Difference of the mean from extreme.	Simple error.	1st microscope next the eye.	Farthest microscope next the object glass.	Mean difference.	Difference of the mean from extreme.	Simple error.
Div[s] from S. pole.		″	″	″	90° 0′	90° 0′	″	″	″
0 ′	0 ′					″			
10 0	10 0					− 1,0	− 0,7	0,5	− 0,35
″	″					− 0,2			
+ 0,2	− 0,3					− 0,8			
− 0,2	− 1,0	− 0,1	− 0,9	− 0,05	100	100			
− 0,3	+ 0,7					+ 1,9			
+ 0,3	− 0,3					+ 0,4	+ 0,9	1,0	+ 0,45
						+ 0,5			
Mean 0,0						+ 1,0			
20 0	20 0				110	110			
	− 0,1					+ 0,5			
	− 0,5	− 0,6	0,6	− 0,3		+ 0,6	+ 0,3	0,5	+ 0,15
	− 1,2					− 0,2			
30	30 0				120	120			
	− 0,5					− 0,5			
	− 1,5	− 0,9	0,6	− 0,45		+ 0,7	+ 0,2	0,7	+ 0,1
	− 0,7					+ 0,4			
					130	130			
40	40 0					− 0,9			
	− 1,0					− 0,6	− 0,4	0,7	− 0,2
	− 0,9	− 1,3	0,7	− 0,65		+ 0,3			
	− 2,0				140°	140			
						+ 0,2			
50°	50 0					− 0,1	+ 0,3	0,4	+ 0,15
	− 2,6					+ 0,7			
	− 3,7	− 3,0	0,7	− 1,5	150°	150			
	− 2,8					− 0,4			
						− 0,3	− 0,4	0,1	− 0,2
52° 10′	52° 10′					− 0,5			
	+ 4,4				160	160			
	+ 5,2	+ 4,7	0,5	+ 2,35		− 0,1			
	+ 4,5					+ 1,2	+ 0,7	0,6	+ 0,35
60°	60.					+ 0,2			
	− 1,5					+ 0,7			
	− 1,0	− 0,7	0,8	− 0,35	170	170			
	+ 0,4					+ 1,2			
70	70.					+ 0,4	+ 0,6	0,6	+ 0,3
	− 1,4					+ 0,3			
	− 2,0	− 2,0	0,6	− 1,0	180	180			
	− 2,6					+ 0,4			
80°	80.					+ 0,0	+ 0,5	0,1	+ 0,25
	+ 2,4					+ 0,4			
	+ 3,1	+ 2,7	0,4	+ 1,35					
	+ 2,6				Mean	of all	+ 0,04	0,57	

• Denotes a doubtful or bad point.

From the preceding table of observations of the declination circle it appears, that these divisions were very little, if any, inferior in accuracy to those on the equatorial circle. And, finally it appears, that the errors, and probability of error, were as follows; viz. in the equatorial circle, from 22 corresponding observations of opposite divisions,

Obs^{a}.						
In 0, the error amounted to	2″			therefore the probability against this error was		
5.	-	-	about $1\frac{1}{2}$	-	-	$= 3\frac{1}{2}$ to 1
8.	-	-	- 1	-	-	= 2 to 1.
14.	-	-	about $0\frac{1}{2}$	-	-	= 1 to 2

And in the declination circle, from 19 corresponding observations of opposite divisions,

Obs^{a}.				therefore probability against this error,
In 1, the error amounted to about	2″			= 18 to 1
3.	-	-	$1\frac{1}{2}$	= 5 to 1
4.	-	-	1	= 4 to 1
8.	-	-	$0\frac{1}{2}$	= 3 to 2

Therefore from 41 double observations on both circles,

Obs^{a}.					
In 1, the error amounted to	2″	viz.	= 40	to	1
8.	-	-	$1\frac{1}{2}$	= 4	to 1
12.	-	-	1	$= 2\frac{1}{2}$	to 1
22.	-	-	$0\frac{1}{2}$	= 1	to 1

We may conclude, therefore, that in both circles no error of more than 2″ need be apprehended from the centre, and from the divisions taken together; and that in general it will probably not exceed 1″, on condition that the micrometer screw head is read off thrice, which in some observations

may be done, if necessary. Lastly, from taking a mean of all the numbers in the 4th column, it seems the probable error, in reading off the divisions, is only $0''{,}53$ in the equatorial circle, and $0''{,}57$ in the declination circle. This source of error may therefore be put at $0''\frac{1}{2}$; so that if one quadrant only of the circle should be made use of, viz. only one micrometer, and that only once read off, it is probable that no error of more than $1''\frac{1}{2}$ will be committed. I mention this, because it will sometimes happen that only one such observation can be made; but where sufficient leisure will allow the reading off both the microscopes, this small error of $1''\frac{1}{2}$ will probably be halved; and if the declination circle be turned half round, and the observation repeated, in the same manner, upon the two remaining quadrants of the circle, as is done (we shall presently see) when the line of collimation is examined, this error will probably be quartered, or reduced to less than $0''\frac{1}{2}$.

After the very rigorous examination the divisions of these two circles have now undergone, and from the general knowledge that I have had opportunities to obtain of the state of practical astronomy in different countries; and when I consider that the celebrated artist, the late Mr. JOHN BIRD, seems to have admitted a probable discrepancy in the divisions of his 8 feet quadrants, amounting to * $3''$, I think I am entitled to believe that the accuracy of these divisions under consideration is hardly to be equalled, and still less to be excelled, by that of any astronomical instrument in Europe; and, from the unexampled diligence and care, with which the skilful artist Mr. MATTHEW BERGE, workman to Mr. RAMS-

* See Mr. BIRD's Method of constructing Mural Quadrants. London, 1768.

DEN, has executed them, I feel myself bound to bear this testimony to his merit.

(22.) It remains that I now say something of the power of the telescope; for it is to little purpose that the divisions be accurate, or the levels sensible, unless the force of the telescope be such as to correspond with the sensibility of the one, and the accuracy of the other. The object glass is a well corrected double achromatic, whose joint focus is 65 inches, with an aperture of 4,2 inches. The telescope is furnished with two sets of eye glasses, one single, the other double; of these latter there are 6, of different magnifying powers, from 60 to 360 times; of the former there are 5, with powers from 150 to 550. To these may be added a prism eye tube, with a power of about 100, for objects near the zenith, or the pole, and similar to the one described by General ROY; (see Philosophical Transactions, Vol. LXXX. p. 155) also a tube with a divided eye glass micrometer; (see Philosophical Transactions, Vol. LXIX.) it has a power of 80, but the images are not distinct, or equally bright, and the extent of the scale is so small, not more than 10′, that it is, in truth, but of little use. The double eye tubes are composed of two eye glasses, to enlarge the field and render it more agreeable, both placed on the hither side of the cross wires, so that they may at any time be changed, without deranging the wires. The lowest of the compound eye tubes, with a power of about 60, is what is generally used for transits and polar distances.* For telescopical observations

* If, as has been generally imagined, an angle of 1′ is about the smallest that is visible to the naked eye, (SMITH's Optics, § 97) with a power of 60 times 1″ will become visible; and, in that case, the power of this telescope will correspond with the levels, and the divisions, as was required above.

of the planets, higher powers may be put on; and of these, that of 400 seems to be near the maximum that this glass will bear; with 500 the image is not so well defined; with 200 or 300, it is beautifully distinct and bright; but this inquiry demands more experiments than I have hitherto made, having been able to procure these high powers only within a few weeks.

(23.) Having now given, as I apprehend, a very satisfactory idea of the accuracy of the parts of this instrument, I shall proceed to the method of adjusting them. This machine, not being capable of having its polar axis laid horizontal, its adjustments, in some respects, will be different from those of small instruments of the same name. (See the methods proposed by Mr. RAMSDEN, in his Description, and by Mr. VINCE, in his Practical Astronomy.) It may be proper to premise, that the principal points required are, 1st. to adjust the level P, *k*, parallel to the declination axis U, V. 2dly, to adjust this axis at right angles to the line of collimation of the telescope; and, 3dly, to make this axis at right angles to the polar axis.

Probably others may be devised, but the mode I have adopted is as follows.*

The polar axis is placed nearly in the meridian, by means of a meridian mark, previously verified, and elevated pretty nearly to the latitude of the place. This is to be done more accurately afterwards, by the sliding plates, and screws, at the bottom of the polar axis.

* Whoever is desirous of seeing some very ingenious disquisitions of the errors and adjustment of this instrument, will do well to consult the Abbé BOSCOVICH'S *Opera pertinentia ad Astronomiam et Opticam*, quarto, Bassani, 1785. Tomi 4ti Opusculum 14tum.

The axis of the declination circle is then brought nearly horizontal, by its proper level, viz. is turned round about the polar axis, till the bubble of the level stands true between the indexes; the instrument is then turned half round about the polar axis, = 180°, shewn by the microscope W. If the bubble then stand true, it requires no correction, but if it do not, correct half the error, by moving the equatorial circle by its handle *t*, and the other half by the capstan screw *a*; (Tab. XIV. fig. 1) then turn the instrument back again to its first position, and see if the level stand true; if not, repeat this operation till it does, correcting one half of the error by the equatorial handle, and the other half by the screw *a*. The declination axis will then be parallel to the level, and both of them to the horizon. It must be remarked, that in this operation it will be necessary to move the declination circle round its own axis a little, in order to bring the same side of the level uppermost; but this in no degree affects the result, for the imaginary line, round which this axis revolves, is what is meant all along by the axis, and is the line to which the parallelism of the level is referred.

The declination axis remaining in an horizontal position, with the level above the axis, as in Tab. IX. turn the declination circle 180°, viz. till the level become below the axis; then, by means of the pinion *b*, restore the tube of the level to an upright position, and see if the bubble stand true; if not, correct $\frac{1}{2}$ the error by the screw *c*, and the other $\frac{1}{2}$ by *a*. Now turn the declination circle 90° each way from its last situation, and repeat the examination of the bubble, and correct, as before, $\frac{1}{2}$ by the screw *b*, at right angles to *c*, and $\frac{1}{2}$ by the screw *i*; and if, after all these

corrections, in every part of an entire revolution of the declination circle round its axis, and of the level round its axis, the bubble stand true, it follows, that the axis of the declination circle, and of the level, are in every direction parallel to each other, both of them to the tangent of curvature in the middle of the level, and all three to the horizon. This adjustment is therefore complete.

(24.) It remains to be seen, whether the line of sight of the telescope is at right angles to the declination axis, and this latter to the polar axis.

Take the error of the collimation of the telescope in right ascension, by a star in the equator, viz. let the transit of a star in the equator over the assumed meridian be observed, with the declination circle turned towards the east, and also towards the west. If there be any difference in these observations, it will denote double the error of collimation in right ascension, and half of it will be the deviation of the line of sight from a line at right angles to the axis of the declination circle; and is correspondent to a similar adjustment of a transit instrument. The amount of this error being thus ascertained, let it be corrected by the screws, at the eye end of the telescope, that move the wires to the east and west. The declination axis, by means of its level, being restored to an horizontal position, let the centre wire of the telescope (by which is always understood the line of collimation) be brought to bisect the meridian mark, by means of the sliding plate and adjusting screw below the polar axis, the telescope will then become a complete transit instrument; for, by the *first* operation, the declination axis is made parallel to the level and its axis, and both to the horizon; by the *second*, the line of sight is put

at right angles to this axis; and *thirdly*, it is adjusted to the meridian.

Now, let the error of collimation in right ascension, in the same manner, be observed with any star out of the equator, by a circumpolar star, (the nearer the pole the better) suppose the pole star. If any difference should be noticed in its passage, with the circle east or west, halve that difference,* and it will be equal to the angle that the plane of the declination circle makes with the polar axis, if the observed star were actually in the pole; if not, divide it by the sine of its declination, and the true angle of the plane of this circle (or of the line of collimation) with the polar axis, will be had. Again, if this operation be repeated with any other stars, and the error so found be divided by the sine of their declination, the error of the plane of the declination circle at the pole, viz. its greatest error, or angle with the polar axis, will be had. And note, if these observations are made with stars on each side of the equator, these quantities will be had in opposite directions. Finally, the same may be done by two land objects, one to the north, and the other to the south; the north and south meridian marks, for instance, proper consideration being had to their declination; by this means the error will be thrown in contrary senses, or doubled, and, from a variety of such results, a very correct *mean* quantity may ultimately be

* By difference is here meant, the difference taken in minutes and seconds of a great circle passing through the star, and which can only be directly measured by a micrometer; but if, as is most convenient, this quantity should be observed by time, or by the divisions on the equatorial circle, (15 and 16) this quantity must be diminished in the proportion of the radius to the sine of the polar distance, viz. multiplied by the co-sine of the declination; hence it is, that this method is capable of great precision.

deduced; and when found, must be corrected by the screws* at one end of the declination axis. I have been rather diffuse in the account of this adjustment, because it is one of the most important in the whole instrument, and does not readily present itself.

It has now been seen that, 1st, the level and its axis are parallel to the axis of the declination circle. 2dly, the line of sight at right angles to this axis, and parallel to the polar axis; and consequently the declination axis at right angles to the polar axis. 3dly, the polar axis parallel to that of the earth. These are the chief requisites in the adjustment of this instrument. Those that remain are secondary, and I shall take them in the following order. 1st. The adjustment of the cross wires to the focus of the telescope. 2dly. The hanging level. 3dly. The line of collimation, north and south, as well as east and westward. 4thly. The index wires in the microscopes. 5thly. The refraction apparatus. And, 6thly, the power and scale of the microscopes.

(25.) First, the cross wires. Let the eye tube be adjusted to distinct vision for parallel rays by some distant object, such as Jupiter, Saturn, or Venus, by daylight; that done, observe, while one limb of either of these planets appears running along the equatorial wire, whether any motion of the eye, upwards or downwards before the eye glass, alters the relative place of the image and the wire; if a motion of the eye upwards moves the planet in the *same* direction, the wires are too near the eye glass, and must be pushed in; and *vice versâ*, till the image become fixed upon the wire, what-

* The heads of these screws being divided into 10 parts, and the value of each known, any given correction is easily applied.

ever be the motion of the eye. When this point is obtained, the eye stop with its wires, must be there fixed, for that is their true place; viz. the correct focal point of the object glass; and whatever indistinctness may be found, from the diversity of eyes of different observers, must be corrected by the motion of the eye glass only. Another point to be secured is the permanency, as far as may be, in the position of the object glass; for if this be not correctly centered, which is very rarely the case, and indeed never to be expected, that is, if its axis be not concentric with the axis of the cell, in which it is fixed, any motion of this latter, by screwing or unscrewing it, may not only change the place of the focus, to which the wires are adjusted, but will necessarily move the line of collimation, both in right ascension and declination.* To obviate this, therefore, two corresponding marks should be made, with a graver, both upon the cell, into which the glass is burnished, and also upon the tube of the telescope, into which the cell is screwed, or otherwise inserted, that in case the object glass should ever be taken out to clean it, &c. it may be restored very nearly, if not exactly, to its former position.

The eye glass, object glass, and wires, being thus settled in their respective places to each other, it will not be an improper time to measure the interval between the wires, which cannot be too accurately done, being of such constant use; this may be either, 1st, by observing the passage of a star in the equator, and making proper allowances for the rate of the

* By moving my object glass an entire revolution in its screw, the line of collimation appears to move through a little circle of 50″ in diameter, so that the eccentricity, in this instance, appears to have been about $\frac{1}{100}$ inch.

clock, or by a star out of the equator, and making proper allowance for the declination, in the proportion of the radius to the co-sine: or, 2dly, by means of the equatorial circle and a fixed land object; and here the quantity must be diminished in the same ratio of the radius to the sine of the polar distance. I have made use of both methods, as a confirmation of each other, and find the interval, which is equal in the three wires of my telescope, to be $7'\ 34''{,}5 = 30''{,}3$ sidereal time; and these three wires divide the diameter of the field very nearly into four equal parts.

(26.) Second and third adjustment; the hanging level. By means of its proper handle *u*, move the declination circle about its axis, till the bubble of the hanging level *l*, *m*, rests true between the indexes, there fix it by the clamp *w*, reverse the level, by taking it out of its pivots, and turning it end for end; if the bubble now stand true, the level is adjusted; if not, correct $\frac{1}{2}$ the error by the declination handle, and the other $\frac{1}{2}$ by the small screw at the bottom of the level; then reverse the level, and repeat this operation till it does. The level, or rather a tangent to its curvature at its middle, will be parallel to the axis, on which it swings; and both will be horizontal. At this time look through the telescope, and see what land object is covered by the horizontal wire; now invert the telescope, by turning it 180° round the declination axis, and 180° round the polar, and bringing the level true, it will then point to nearly the same place; and if exactly the same object as before be now covered by the horizontal wire, the axis of the level is adjusted parallel to the line of collimation, in a vertical direction; if not, correct half the error by the little capstan screw at the bottom of the cock, or arm,

that supports one end of the axis of the level, and the other half by the declination handle; invert the telescope, and repeat the operation till the same object is covered in both positions, and the level is found true; then will the level and its axis be parallel to the line of collimation, and the object covered by the wire may be concluded to be in the horizon.

(27.) Fourth. The index wires of the microscopes. The line of collimation, with respect to east and west, has been already adjusted as above (sect. 24.) Let then the declination axis, by its level, be restored to an horizontal position; at this time adjust the index wires in the two equatorial microscopes W X, to bisect the two opposite divisions 360 and 180°, then will these wires be rectified to their proper place. That being done, bring 90°, or the division that represents the equator on the declination circle, under its respective microscope, and turn the whole instrument one quarter round on the polar axis, viz. till 90° on the equatorial circle be bisected by the micrometer; and if, at this time, the bubble of the hanging level appear true, the index wire of the declination microscope is correct; if not, correct half the error by the declination handle *a*, and half by the little screws *b*, (Tab. XIV. fig. 2) at the side of the hanging level; then reverse the telescope, viz. turn it till 270° on the equatorial circle come under the micrometer wire, and if the level then rest true, the adjustment is complete; if not, repeat the operation, as before, till it does; then, by its proper screw, bring the index wire of the declination micrometers to bisect the points 90 and 90°. The indexes of both circles will be then adjusted, and the axis of the hanging level brought parallel to the line of collimation, with respect to east and west, as well as with respect to

north and south. Note, this parallelism of the axis of the level, to the line of collimation in a direction east and west, does not appear to be a very important rectification, but on some occasions may have its use.

(28.) Fifth. The refraction piece. After what has been done, this apparatus will be easily adjusted. Bring the telescope, by means of its two levels P *k*, and *l m*, to point to the horizon, and in the meridian; then, by the two pinions *f*, *b*, (Tab. X. fig. 2) of the refraction piece, bring *its* two levels *e* and *g* to rest true; move the nonius *d*, of the little semicircle of the horary and vertical angles *a*, *b*, *c*, to the middle of the divisions, or 0° 0′, and also that of the little quadrant of altitude *l*, *k*, to 0° 0′, and this part is adjusted.

(29.) Sixth. The microscopes. The magnifying power and scale of the microscopes is all that remains to be considered.

The magnifying power of a compound microscope, as is well known, (see SMITH's Optics, § 197) depends on the proportion between the distance of the object, and of its image, from the object glass, together with the proportion between the focus of the eye glass, and ordinary focus of the eye, looking at a small object (suppose of $\frac{1}{50}$ or $\frac{1}{100}$ inch). These two ratios compounded give the power of the microscope. The former is called magnifying by distance, and is a material part in the construction of these microscopes; the scale of the micrometer being regulated by this part of the magnifying power. For example, let the distance of the object from the glass be = 1, and the distance of its image = 4, its power will be 4; and consequently the scale of the micrometer, or motion of its screw, to answer to 10′, (suppose) must be

4 times as great as the space occupied by 10′ on the limb of the circle; and if the radius of the circle be 2 feet, an arc of 10′ will be equal to 0,07 inch nearly, on the limb; and = 0,28 inch on the scale, viz. = to the same arc on a circle of 8 feet radius; and if each revolution of the micrometer screw be intended to describe 1′, the screw must contain about 35 threads in an inch. But as it would be difficult to adjust the screw *exactly* to the scale, the advantage of the construction of these micrometers is, the scale may at any time be adjusted to the screw; for let the interval between any two nearest divisions, = 10′, on the limb, be measured by the screw, and suppose, instead of being = 10′ or 600″, it appears only = 570″; it is evident, that the scale is bigger than it should be, or, which is the same thing, that the image is less by $\frac{10}{600}$ or $\frac{1}{20}$. In this case increase the distance between the micrometer wires, and the object glass, = $\frac{1}{20}$, by unscrewing or drawing out the tube, that carries the micrometer and eye glasses, and the scale is adjusted. It will at the same time, however, be necessary to re-adjust the object glass of the microscope to distinct vision, by the screw of the cell, that contains it, until the image and the wires have no relative change of place by any motion of the eye. This will again occasion some small alteration in the scale, and must be corrected by repeated trials, and the scale adapted to the divisions on the arc; and if the moveable wire of the microscope be now brought to coincide exactly with the fixed one, and the moveable index (with the mark ⏚) brought to zero (0) on the screw head, the micrometer is completely adjusted. This having been done with all the microscopes, and the opposite ones being made to agree, each with the other, in such

manner, that the fixed wires may become a correct diameter, I believe the whole instrument will have been completely adjusted.

(30.) Before I conclude this account, I must beg leave to trouble the reader's patience a few minutes more, in order to give a general idea of the manner of making the ordinary observations of right ascension and declination, with this instrument.

Let the telescope be adjusted towards the meridian mark, in such manner that the centre wire may exactly bisect it; then note if the index wire of the equatorial micrometers bisect the points of 360° and 180°. If it does, the instrument is prepared for observing a transit; if not, and the difference be considerable, it must be corrected by moving the polar axis, by its adjusting screw. But as this quantity will seldom exceed 8″ or 10″, it will be more convenient to note this quantity in the journal, and allow for it afterwards in reducing the observations.* As this quantity will from time to

* This may be done by the following rule.

$\text{Æ} \times \text{sine P} \times \frac{\text{sine zenith dist.}}{\text{sine polar dist.}} = x$ the correction + or − according as the telescope points to the east or west of the meridian.

Where Æ is = the error on the equatorial circle,

And P = the angle that the polar axis makes with a ray from the meridian mark.

And if there should appear any error in the horizontal position of the axis of the declination circle at this time, by the level not standing true, that error may be corrected by this theorem.

$\text{D} \times \frac{\text{sine alt.}}{\text{sine polar dist.}} = x$ the correction.

Where D is = angle of depression of one end of this axis below the horizon.

And by means of the above theorems, a table may be calculated that will give these corrections always, by inspection; such a table I have computed for my own use, but

time be variable, from a variety of causes, such as the possible settling of the walls of the building; the partial or irregular expansion of the instrument, from the sun-beams accidentally falling upon it; from the effect of a fire in the room, or the heat of a person's body in cold weather; from the sun's heat upon the meridian mark, eastward in the morning, and westward in the afternoon; from the same effect upon the observatory; and lastly, possibly from a *lateral* refraction of the ray coming from the meridian mark, from irregular vapours floating near the surface of the earth. From some, or all of these causes, this quantity of error will be found to be exactly the same hardly for two days together; but I have never yet known it to exceed 13″ of a degree, = 0″,7 in time, during a period of more than a year, and very rarely above 6″ or 7″, sometimes on one side, and sometimes on the other. When this error is known, and set down, move the instrument about the polar axis by its handle *t*, till the divisions 360 and 180° are bisected by the equatorial wire; this done, move the declination circle by its handle *n*, till the hanging level stands true; and note the division on the declination circle cut by the micrometer wire, for that is the horizontal point, from whence the altitudes are to be reckoned. If the order of the divisions be such as to shew declinations, this division will be the angle of the co-altitude of the polar axis; but if the divisions be such as in my instrument, it will be equal to the altitude of the polar axis, which *should* be equal to the latitude of the place. But

as it is suited only to one latitude it is not given here. Tables, something similar to this, may be seen in Mr. Ludlam's Astronomical Observations, Cambridge, 1769; and also in the *Connoissance des Temps, pour* 1792, p. 251.

as this will seldom happen, from the same reasons as have already been mentioned, I prefer taking a memorandum of this quantity also, and allowing for it; by which means I see its alteration, from time to time, compared with the weather, know better what I am about, than if I attempted to correct it, and save a great loss of time. From hence it must be seen that nothing is depended on, but that the instrument keeps its place during the four or five minutes that the observer is occupied in making the observation.

(31.) The instrument is now prepared for an observation over the meridian, and also of the polar distance; at which moment, if the weather should be cloudy, the observation incomplete, or unsatisfactory, it may be repeated as many times afterwards as is thought proper, taking notice of the distance from the meridian, shewn in the equatorial microscopes, and making allowance, in the reduction, for the motion of the sun, or planet, during the interval; for I esteem an observation made within 10 or 15° of the meridian, nearly equivalent to a meridian observation. But, if an observation should be made out of the meridian, the altitude and angle of the horary and vertical circles must be taken, by the refraction apparatus; and with these arguments, the refraction and parallax, in north polar distance, and in right ascension, may be found by inspection, in the tables that follow this account, and consequently every observation readily reduced to the meridian.

(32.) I shall close this long history with an account of the probable accuracy of the observations made with this instrument, viz. of the amount of the probable errors, derived from an experience of more than twelve months. And first, with

respect to those of right ascension. It must be readily seen, that the amount of these errors will be pretty nearly the same as those of any other transit instrument, whose magnifying power, and length of axis, are the same. However, from actual trial, I find that the passage of a star, near the equator, over any one wire in the field of the telescope, may be determined to within $\frac{1}{5}$ of a beat of the regulator, in strictness to about 3″,7, and, from a mean of the three wires, to within 1″,25 of a degree, $= \frac{1}{12}$ of a second of time; that is, if the wind be still, the weather favourable, and reasonable care be taken. And, from a series of observations of the sun's diameter throughout the year, it appears, the error in ordinary observations may be expected to lie within 3″; that it is 17 to 1 that this error does not amount to 5″, $= \frac{1}{3}$ of a second of time; and this includes some of the worst weather in which observations are likely to be made. I shall therefore say, that

The probability of error of an observation of a transit over the meridian, under tolerably favourable circumstances, from a mean of 3 wires, viz. in estimating the beat of the regulator, is about - - - - = 2,0

Add to this the error of setting the instrument to the meridian mark - - - - = 1,0

Add, also, the error in reading off the equatorial microscope - - - - - = 0,5

Total error of an observation *in* the meridian becomes - - - - = 3,5

To this add the error of the divisions, and of the centre (at most) - - - - = 1,0

Also the second reading off of the microscope - = 0,5

And the total error of an observation of a transit out of the meridian, will be - - - = 5,0

The same, from actual experiment, in 19 trials, within 15', on each side of the meridian (in February, 1792) - - - - = 7,5

That is, that an observation made out of the meridian, will give the transit over the meridian true to $\frac{1}{4}$ a second of time.

The error in the observation of a polar distance may be put as follows.

Error of the eye, in estimating the coincidence of the wire in the telescope with the object, the power being 60 times - - - - = 1,

Error of the divisions, and of the centre, in taking the horizontal point in the circle - - - = 1,

Error in reading this division off by the microscope - - - - = 0,5

Error of the level, in ordinary observations - = 2,

Error of the divisions, and centre, a second time, viz. in taking the angle of the polar distance - = 1,

Error in reading off this division by the microscope = 0,5

Sum of all these errors - - - = 6,0

Ditto, by actual observation of the line of collimation, the circle being turned east and west, from various experiments, appears to be - - 7,5

Lastly, if care be taken in the observation, and the

sun not suffered to shine on the instrument, only during the moment of observation, I think no error in the polar distance need be apprehended exceeding 7,

And in the meridian passage, none exceeding - 5,5

So that it appears, that the right ascension will be observed with twice the precision of the polar distance.

And here we must not omit to take notice, that of all the above mentioned causes of error, one only, viz. the error of the divisions in taking the polar distances, appears to be fixed, so that, by repeating the observation, the truth may be approached to any given degree of accuracy. I have thought proper to make these remarks on the errors of the instrument, that if health and leisure should enable me hereafter to offer to the Royal Society the result of any astronomical observations with it, it may be known to what claim to precision they are entitled.

In describing the instrument, the following references in Tab. IX. were omitted in the text.

ff, gg, bb, ii, are the eight conical radii to the declination circle, described page 78.

11, 12, are two supporters to the clamp and endless screw, page 80.

36, is a pair of steps, for the convenience of the observer.

Explication and Use of the following Tables.

The three first Tables are particularly calculated for the use of the large equatorial instrument, for the purpose of clearing observations with it from the effects of refraction and parallax. The four last are adapted more peculiarly to the small or portable equatorial, such as has been noticed in sect. 10, and which I thought might be acceptable to such persons as have the good fortune to possess one of these instruments. Of these Tables in their order.

Table I. gives the correction of the refraction in north polar distance, by entering it with the altitude at the top, and the angle of the horary and vertical circles on the left hand side; and in the common point of meeting is found a quantity, in seconds and decimals, that is to be added to the *apparent* polar distance, to give the *true*; this correction is always additive. But if the same table be entered with the angle of the horary and vertical circles, in the right hand column, it will give the refraction in right ascension, by multiplying the quantity here found by the secant of the declination, to be found in Table IV.

Table II. gives the effect of the sun's parallax in right ascension and north polar distance, and is to be entered with the same arguments as Table I.; and the parallax in right ascension is to be multiplied by the secant of the declination, as before; the sun's horizontal parallax being assumed $= 8'',6$.

Table III. is a similar Table, only calculated to an horizontal parallax of $10''$: so that whatever be the parallax of the sun or planets, this correction may readily be found, almost by inspection.

Table IV. is the natural secants to each degree, extracted from SHERWIN'S Tables; being of such constant use in these computations, I have placed it with these tables of refraction.

Table V. gives the correction of the time; viz. of the sun or star's distance from the meridian, in an observation with a portable equatorial, not previously adjusted to the meridian; this quantity is to be multiplied also by the secant of the declination.

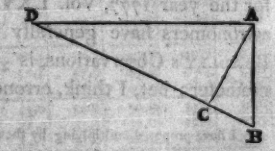
Table VI. as its title imports, gives the correction of the meridian line in minutes and decimals, which was thought near enough for a portable instrument; the quantity here found is to be multiplied by the secant of the altitude.

Table VII. similar to Table I. only reduced to seconds of time, gives the refraction in right ascension, suited to the usual mode of dividing the small instrument; viz. into civil hours and minutes.

Table VIII. similar also to Table I. gives the refraction in declination. The arguments are the same in all the Tables; viz. the altitude, and the angle of the horary and vertical circles; which appeared to me the only means of making the Tables universal, and adapted to all latitudes.*

Their foundation is this:

Let AB be a portion of a vertical circle = the refraction in altitude; DA a parallel to the horizon; and DB a paral-



* A table of refraction in right ascension and declination, for the latitude of Paris *only*, may be met with in the *Connoissance des Temps, pour* 1791. What I have given in the following account, viz. Tab. V. VI. VII. and VIII. I calculated for my own use, as early as the year 1774.

lel to the equator: then AC will be a portion of an horary circle = the refraction in declination, found by Table I. and Table VIII. ∠ CAB, the angle of the horary and vertical circle; CB, the refraction in right ascension, found by Table I. and Table VII. DA, the correction of the meridian, found by Table VI.; and DB, the correction of the time, found by Table V.; and, as AB will hardly ever be found to exceed 30′, these triangles have been considered all as plane; making due allowance, in the proportion of the sine to the radius, for the distances of the arcs DA, BC, and DB from their respective poles, which has been noticed at the foot of each Table.* The refraction in altitude having been taken from Professor MAYER'S Tables, London edition, 1770, which is calculated for a density of the air, expressed by 29,6 inches of the barometer, and 50° of FAHRENHEIT'S thermometer; and, for any other heights of the barometer and thermometer, may be corrected in the usual way; making an allowance for each degree of FAHRENHEIT'S thermometer, above or below 50°, of $\frac{1}{4259}$. This correction has been deduced from the result of a great many observations that I made some years since with the manometer, described in the Philosophical Transactions for the year 1777, Vol. LXVII. p. 564. The equation that astronomers have generally been used to adopt, from Dr. BRADLEY'S Observations, is $\frac{1}{400}$ for each degree of the thermometer; but, I think, erroneously.

* I have proposed multiplying by the secant, instead of dividing by the co-sine, as being the readier operation, and which comes to the same thing.

[To face p. 122.

No I. Table of the Effect of Refraction in North Polar Distance.

This correction is always +.

Angle of the vertical with the horary circle.	DEGREES OF ALTITUDE. 2°	4°	6°	8°	10°	12°	14°	16°	18°	20°	22°	24°	26°	28°	30°	Angle of the vertical with the horary circle.
0	18 1	11 42	8 25	6 30	5 15,6	4 24,0	3 46,4	3 17,5	2 54,7	2 36,3	2 20,9	2 8,0	1 57,2	1 47,6	1 39,0	90
2	18 0	11 42	8 24	6 30	5 15,3	4 23,8	3 46,3	3 17,4	2 54,6	2 36,2	2 20,8	2 7,9	1 57,1	1 47,5	1 38,9	88
4	17 58	11 40	8 24	6 29	5 14,7	4 23,4	3 45,9	3 17,0	2 54,3	2 35,9	2 20,6	2 7,7	1 56,9	1 47,3	1 38,8	86
6	17 55	11 37	8 22	6 28	5 13,8	4 22,5	3 45,2	3 16,4	2 53,7	2 35,4	2 20,1	2 7,3	1 56,6	1 47,0	1 38,5	84
8	17 50	11 35	8 20	6 26	5 12,6	4 21,4	3 44,2	3 15,6	2 53,0	2 34,8	2 19,5	2 6,8	1 56,1	1 46,6	1 38,0	82
10	17 44	11 31	8 17	6 24	5 10,8	4 20,0	3 43,0	3 14,5	2 52,0	2 33,9	2 18,8	2 6,1	1 55,4	1 46,0	1 37,5	80
12	17 37	11 27	8 14	6 21	5 8,7	4 18,2	3 41,4	3 12,8	2 50,9	2 32,9	2 17,8	2 5,2	1 54,6	1 45,2	1 36,8	78
14	17 29	11 21	8 10	6 18	5 6,3	4 16,2	3 39,7	3 11,6	2 49,5	2 31,7	2 16,7	2 4,2	1 53,7	1 44,4	1 36,1	76
16	17 19	11 15	8 5	6 15	5 3,3	4 13,7	3 37,6	3 9,8	2 47,9	2 30,2	2 15,4	2 3,0	1 52,7	1 43,4	1 35,2	74
18	17 8	11 7	8 0	6 11	5 0,3	4 11,1	3 35,3	3 7,8	2 46,1	2 28,7	2 14,0	2 1,7	1 51,5	1 42,3	1 34,1	72
20	16 56	11 0	7 54	6 7	4 56,7	4 8,1	3 32,8	3 5,6	2 44,1	2 26,9	2 12,4	2 0,3	1 50,1	1 41,1	1 33,0	70
22	16 41	10 51	7 46	6 1	4 53	4 4,8	3 29,9	3 3,2	2 42,0	2 24,9	2 10,6	1 58,7	1 48,7	1 39,7	1 31,8	68
24	16 28	10 41	7 41	5 56	4 48	4 1,2	3 26,9	3 0,5	2 39,6	2 22,8	2 8,7	1 56,9	1 47,1	1 38,3	1 30,4	66
26	16 12	10 31	7 34	5 50	4 44	3 57,3	3 23,5	2 57,6	2 37,0	2 20,5	2 6,6	1 55,0	1 45,4	1 36,7	1 29,0	64
28	15 55	10 20	7 26	5 44	4 39	3 53,1	3 20,0	2 54,5	2 34,2	2 18,0	2 4,4	1 53,0	1 43,5	1 35,8	1 27,4	62
30	15 36	10 8	7 17	5 38	4 33	3 48,6	3 16,1	2 51,1	2 31,3	2 15,1	2 2,0	1 50,8	1 41,5	1 33,1	1 25,7	60
32	15 17	9 55	7 8	5 31	4 28	3 43,9	3 12,0	2 47,6	2 28,1	2 12,6	1 59,5	1 48,5	1 39,4	1 31,2	1 24,0	58
34	14 56	9 42	6 58	5 23	4 22	3 38,9	3 7,8	2 43,8	2 24,8	2 9,6	1 56,8	1 46,1	1 37,2	1 29,1	1 22,1	56
36	14 34	9 28	6 48	5 16	4 15	3 33,6	3 3,2	2 39,9	2 21,3	2 6,5	1 54,0	1 43,6	1 34,9	1 27,0	1 20,1	54
38	14 12	9 13	6 38	5 7	4 9	3 28,0	2 58,4	2 35,6	2 17,6	2 3,2	1 51,0	1 40,9	1 32,4	1 24,7	1 18,0	52
40	13 48	8 58	6 27	4 59	4 2	3 22,2	2 53,4	2 31,3	2 13,7	1 59,8	1 47,9	1 38,0	1 29,8	1 22,3	1 15,8	50
42	13 23	8 41	6 15	4 50	3 55	3 16,1	2 48,2	2 26,7	2 9,7	1 56,1	1 44,7	1 35,1	1 27,1	1 19,9	1 13,5	48
44	12 58	8 25	6 3	4 40	3 47	3 9,9	2 42,9	2 22,1	2 5,6	1 52,4	1 41,4	1 32,1	1 24,4	1 17,4	1 11,2	46
46	12 31	8 7	5 51	4 31	3 39	3 3,4	2 37,3	2 17,1	2 1,4	1 48,6	1 37,9	1 28,9	1 21,5	1 14,7	1 8,8	44
48	12 3	7 49	5 38	4 21	3 31	2 56,6	2 31,5	2 12,1	1 56,9	1 44,6	1 34,3	1 25,6	1 18,5	1 12,0	1 6,2	42
50	11 35	7 31	5 24	4 11	3 23	2 49,7	2 25,6	2 6,9	1 52,3	1 40,5	1 30,6	1 22,3	1 15,4	1 9,1	1 3,6	40
52	11 6	7 12	5 11	4 0	3 14	2 42,5	2 19,3	2 1,6	1 47,5	1 36,6	1 26,8	1 18,8	1 12,2	1 6,2	1 1,0	38
54	10 35	6 52	4 57	3 49	3 6	2 35,2	2 13,8	1 56,6	1 42,7	1 31,9	1 22,9	1 15,2	1 9,0	1 3,2	58,2	36
56	10 4	6 33	4 42	3 38	2 57	2 27,6	2 6,6	1 50,5	1 37,7	1 27,4	1 18,8	1 11,6	1 5,6	1 0,1	55,4	34
58	9 33	6 12	4 27	3 27	2 47	2 19,9	2 0,0	1 44,7	1 32,6	1 22,9	1 14,7	1 7,8	1 2,2	57,0	52,5	32
60	9 0	5 51	4 12	3 15	2 38	2 12,0	1 53,2	1 38,7	1 27,3	1 18,1	1 10,4	1 4,0	58,6	53,8	49,5	30
62	8 27	5 30	3 57	3 3	2 28	2 3,9	1 46,3	1 32,7	1 22,2	1 13,3	1 6,2	1 0,1	55,0	50,5	46,5	28
64	7 54	5 8	3 41	2 51	2 18	1 55,7	1 39,3	1 26,6	1 16,6	1 8,5	1 1,8	56,1	51,4	47,1	43,4	26
66	7 19	4 46	3 25	2 39	2 8	1 47,4	1 32,1	1 20,3	1 11,1	1 3,5	57,3	52,1	47,7	43,7	40,3	24
68	6 45	4 23	3 9	2 26	1 58	1 38,9	1 24,9	1 14,0	1 5,5	58,5	52,8	47,9	43,9	40,3	37,1	22
70	6 10	4 0	2 52	2 13	1 48	1 30,3	1 17,5	1 7,6	59,8	53,5	48,2	43,8	40,1	36,7	33,9	20
72	5 34	3 37	2 36	2 1	1 37	1 21,6	1 9,9	1 1,1	54,0	48,3	43,6	39,6	36,3	33,2	30,6	18
74	4 58	3 13	2 19	1 47	1 27	1 12,8	1 2,4	54,5	48,1	43,1	38,9	35,3	32,6	29,6	27,3	16
76	4 22	2 50	2 2	1 34	1 16	1 3,9	0 54,8	47,8	42,1	37,8	34,1	31,0	28,4	26,0	24,0	14
78	3 45	2 26	1 45	1 21	1 5	0 54,9	47,1	41,1	36,1	32,5	29,3	26,6	24,3	22,4	20,6	12
80	3 8	2 2	1 27	1 7	0 55	45,8	39,3	34,3	30,2	27,1	24,4	22,2	20,3	18,6	17,2	10
82	2 30	1 38	1 10	0 54	0 44	36,7	31,6	27,5	24,3	21,7	19,6	17,8	16,3	14,9	13,8	8
84	1 53	1 13	0 53	0 41	0 33	27,6	23,5	20,7	18,4	16,3	14,7	13,4	12,2	11,4	10,3	6
86	1 15	0 49	0 35	0 27	0 22	18,4	15,8	13,7	12,3	10,9	9,8	8,9	8,2	7,5	6,9	4
88	0 38	0 25	0 17	0 13	0 11	9,3	7,9	6,9	6,2	5,5	4,9	4,5	4,1	3,8	3,5	2
90	0 0	0 0	0 0	0 0	0 0	0 0,0	0 0,0	0 0,0	0 0,0	0 0,0	0 0,0	0 0,0	0 0,0	0 0,0	0 0,0	0

Refraction in right ascension, × sec^t declination.

This correction is — on the east, and + on the west side of the meridian.

[To face p. 122.

No I. Table of the Effect of Refraction in North Polar Distance, continued.

This correction is always +.

Angle of the vertical with the horary circle.	DEGREES OF ALTITUDE.															Angle of the vertical with the horary circle.
	32°	34°	36°	38°	40°	42°	44°	46°	48°	50°	52°	54°	56°	58°	60°	
°	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	″	″	″	″	″	″	″	″	″	°
0	1 31,5	1 24,7	1 18,7	1 13,2	1 8,2	1 3,6	59,3	55,3	51,6	48,1	44,9	41,7	38,7	35,8	33,1	90
2	1 31,4	1 24,6	1 18,7	1 13,2	1 8,2	1 3,6	59,3	55,3	51,6	48,1	44,9	41,7	38,7	35,8	33,1	88
4	1 31,3	1 24,5	1 18,5	1 13,2	1 8,0	1 3,4	59,2	55,2	51,5	48,0	44,8	41,6	38,6	35,7	33,0	86
6	1 31,0	1 24,2	1 18,3	1 12,8	1 7,8	1 3,3	59,0	55,0	51,3	47,8	44,7	41,5	38,5	35,6	32,9	84
8	1 30,6	1 23,9	1 17,9	1 12,5	1 7,5	1 3,0	58,7	54,8	51,1	47,6	44,5	41,3	38,3	35,5	32,8	82
10	1 30,1	1 23,4	1 17,5	1 12,1	1 7,2	1 2,6	58,4	54,5	50,8	47,4	44,2	41,1	38,1	35,3	32,6	80
12	1 29,5	1 22,8	1 17,0	1 11,6	1 6,7	1 2,2	58,0	54,1	50,5	47,0	43,9	40,8	37,8	35,0	32,4	78
14	1 28,8	1 22,2	1 16,4	1 11,0	1 6,2	1 1,7	57,5	53,7	50,1	46,7	43,6	40,5	37,5	34,7	32,1	76
16	1 28,0	1 21,4	1 15,6	1 10,4	1 5,6	1 1,2	57,0	53,2	49,6	46,2	43,2	40,1	37,2	34,4	31,8	74
18	1 27,0	1 20,5	1 14,8	1 9,6	1 4,9	1 0,5	56,4	52,6	49,1	45,7	42,7	39,6	36,8	34,0	31,5	72
20	1 26,0	1 19,7	1 13,9	1 8,8	1 4,1	59,8	55,7	52,0	48,5	45,2	42,2	39,2	36,3	33,6	31,1	70
22	1 24,9	1 18,5	1 12,9	1 7,9	1 3,2	59,0	55,0	51,3	47,9	44,6	41,6	38,6	35,9	33,2	30,7	68
24	1 23,6	1 17,4	1 11,9	1 6,9	1 2,3	58,2	54,2	50,5	47,1	43,9	41,0	38,1	35,3	32,7	30,2	66
26	1 22,3	1 16,1	1 10,7	1 5,8	1 1,3	57,2	53,3	49,7	46,4	43,2	40,3	37,4	34,8	32,2	29,8	64
28	1 20,9	1 14,8	1 9,5	1 4,7	1 0,2	56,2	52,4	48,9	45,6	42,5	39,6	36,8	34,2	31,6	29,2	62
30	1 19,3	1 13,3	1 8,1	1 3,4	59,1	55,2	51,4	47,9	44,8	41,6	38,9	36,1	33,5	31,0	28,7	60
32	1 17,7	1 11,7	1 6,7	1 2,1	57,9	54,0	50,3	46,9	43,8	40,8	38,1	35,3	32,8	30,3	28,1	58
34	1 15,8	1 10,2	1 5,2	1 0,7	56,6	52,7	49,2	45,9	42,8	39,9	37,2	34,5	32,0	29,6	27,5	56
36	1 14,0	1 8,5	1 3,6	59,3	55,2	51,5	48,0	44,8	41,8	38,9	36,3	33,7	31,3	28,9	26,8	54
38	1 12,1	1 6,7	1 1,9	57,7	53,8	50,1	46,8	43,6	40,7	37,9	35,4	32,8	30,4	28,2	26,1	52
40	1 10,1	1 4,8	1 0,2	56,1	52,3	48,8	45,5	42,4	39,6	36,9	34,4	31,9	29,6	27,4	25,4	50
42	1 8,0	1 2,8	58,4	54,4	50,7	47,3	44,1	41,2	38,4	35,8	33,3	30,9	28,7	26,5	24,6	48
44	1 5,9	1 0,8	56,5	52,7	49,1	45,8	42,7	39,9	37,2	34,6	32,3	29,9	27,8	25,7	23,8	46
46	1 3,4	58,7	54,6	50,9	47,4	44,2	41,3	38,5	35,8	33,4	31,2	28,9	26,8	24,8	23,0	44
48	1 1,1	56,7	52,7	49,0	45,7	42,5	39,8	37,0	34,5	32,2	30,0	27,8	25,9	23,9	22,2	42
50	58,8	54,4	50,6	47,1	43,9	40,9	37,8	35,5	33,2	30,9	28,8	26,8	24,9	22,9	21,3	40
52	56,3	52,1	48,4	45,1	42,1	39,2	36,5	34,1	31,8	29,7	27,6	25,7	23,8	22,0	20,4	38
54	53,8	49,7	46,2	43,1	40,2	37,4	34,9	32,5	30,4	28,3	26,4	24,5	22,7	21,0	19,5	36
56	51,2	47,3	44,0	41,0	38,2	35,6	33,2	31,0	28,9	26,9	25,1	23,3	21,6	19,9	18,6	34
58	48,4	44,9	41,7	38,9	36,2	33,7	31,5	29,4	27,4	25,5	23,8	22,1	20,5	18,9	17,6	32
60	45,8	42,3	39,3	36,6	34,1	31,8	29,6	27,6	25,8	24,0	22,5	20,8	19,3	17,9	16,5	30
62	42,9	39,7	36,9	34,4	32,1	29,9	27,9	26,0	24,2	22,5	21,1	19,5	18,1	16,8	15,5	28
64	40,1	37,1	34,4	32,1	30,1	27,9	26,1	24,3	22,7	21,0	19,7	18,2	16,9	15,7	14,5	26
66	37,2	34,4	31,9	29,8	27,8	25,9	24,2	22,6	21,0	19,5	18,3	16,9	15,7	14,5	13,4	24
68	34,3	31,6	29,4	27,4	25,6	23 8	22,2	20,8	19,4	18,0	16,9	15,5	14,4	13,4	12,4	22
70	31,3	29,0	26,9	25,1	23,4	21,7	20,4	18,9	17,6	16,4	15,4	14,3	13,2	12,2	11,3	20
72	28,3	26,2	24,3	22,7	21,1	19,7	18,3	17,1	16,0	14,8	13,9	12,9	12,0	11,0	10,2	18
74	25,3	23,3	21,7	20,2	18,8	17,6	16,4	15,3	14,3	13,2	12,4	11,5	10,6	9,8	9,1	16
76	22,2	20,5	19,0	17,8	16,6	15,4	14,4	13,4	12,5	11,6	10,9	10,1	9,3	8,6	8,0	14
78	19,0	17,6	16,3	15,3	14,2	13,2	12,4	11,5	10,8	10,0	9,4	8,6	8,0	7,4	6,9	12
80	15,9	14,6	13,6	12,8	11,9	11,0	10,3	9,6	8,9	8,3	7,8	7,2	6,7	6,1	5,7	10
82	12,8	11,7	10,9	10,3	9,6	8,9	8,3	7,8	7,2	6,7	6,3	5,7	5,4	5,0	4,6	8
84	9,6	8,8	8,2	7,7	7,2	6,7	6,3	5,8	5,4	5,0	4,7	4,4	4,0	3,8	3,4	6
86	6,5	5,8	5,4	5,2	4,8	4,5	4,2	3,9	3,7	3,4	3,1	2,9	2,6	2,5	2,3	4
88	3,2	2,9	2,7	2,6	2,4	2,3	2,1	2,0	1,9	1,7	1,6	1,5	1,4	1,3	1,2	2
90	0 0,0	0 0,0	0 0,0	0 0,0	0 0,0	0 0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0

Refraction in right ascension, × sec^2 declination.

This correction is — on the east, and + on the west side of the meridian.

And is to be applied to the sun or star's distance from the meridian, observed on the equatorial circle.

[To face p. 122.

No I. Table of the Effect of Refraction in North Polar Distance, continued.

This correction is always +.

Angle of the vertical with the horary circle.	DEGREES OF ALTITUDE.															Angle of the vertical with the horary circle.
	62°	64°	66°	68°	70°	72°	74°	76°	78°	80°	82°	84°	86°	88°	90°	
°	″	″	″	″	″	″	″	″	″	″	″	″	″	″	″	°
0	30,5	28,0	25,5	23,2	20,9	18,7	16,5	14,4	12,3	10,2	8,1	6,1	4,0	2,0	0,0	90
2	30,5	28,0	25,5	23,2	20,9	18,7	16,5	14,4	12,3	10,2	8,1	6,1	4,0	2,0		88
4	30,4	27,9	25,4	23,1	20,8	18,7	16,5	14,4	12,3	10,2	8,1	6,1	4,0	2,0		86
6	30,3	27,8	25,4	23,1	20,8	18,6	16,4	14,3	12,2	10,1	8,1	6,1	4,0	2,0		84
8	30,2	27,7	25,2	23,0	20,7	18,5	16,3	14,3	12,2	10,1	8,0	6,0	4,0	2,0		82
10	30,0	27,6	25,1	22,8	20,6	18,4	16,2	14,2	12,1	10,0	8,0	6,0	3,9	2,0		80
12	29,8	27,4	24,9	22,7	20,4	18,3	16,1	14,1	12,0	10,0	7,9	6,0	3,9	2,0		78
14	29,6	27,2	24,7	22,5	20,3	18,1	16,0	14,0	11,9	9,9	7,9	5,9	3,9	1,9		76
16	29,3	26,9	24,5	22,3	20,1	18,0	15,9	13,8	11,8	9,8	7,8	5,9	3,8	1,9		74
18	29,0	26,6	24,2	22,1	19,9	17,8	15,7	13,7	11,7	9,7	7,6	5,8	3,8	1,9		72
20	28,7	26,3	24,0	21,8	19,6	17,6	15,5	13,5	11,6	9,6	7,6	5,7	3,8	1,9		70
22	28,3	26,0	23,6	21,5	19,4	17,3	15,3	13,3	11,4	9,5	7,5	5,7	3,7	1,8		68
24	27,8	25,6	23,3	21,2	19,0	17,1	15,1	13,1	11,2	9,3	7,4	5,6	3,6	1,8		66
26	27,4	25,2	22,9	20,8	18,8	16,8	14,8	12,9	11,1	9,2	7,3	5,5	3,6	1,8		64
28	26,9	24,7	22,5	20,5	18,4	16,5	14,6	12,7	10,9	9,0	7,1	5,4	3,5	1,8		62
30	26,4	24,2	22,1	20,1	18,1	16,2	14,3	12,5	10,6	8,8	7,0	5,3	3,5	1,7		60
32	25,8	23,7	21,6	19,7	17,7	15,9	14,0	12,2	10,4	8,6	6,9	5,2	3,4	1,7		58
34	25,3	23,2	21,1	19,2	17,3	15,5	13,7	11,9	10,2	8,5	6,7	5,1	3,3	1,7		56
36	24,7	22,6	20,6	18,8	16,9	15,1	13,3	11,6	9,9	8,2	6,5	4,9	3,2	1,6		54
38	24,0	22,1	20,1	18,3	16,5	14,7	13,0	11,3	9,7	8,0	6,4	4,8	3,1	1,6		52
40	23,4	21,4	19,5	17,8	16,0	14,3	12,6	11,0	9,4	7,8	6,2	4,7	3,1	1,5		50
42	22,7	20,8	18,9	17,2	15,5	13,9	12,3	10,7	9,1	7,6	6,0	4,5	3,0	1,5		48
44	22,0	20,1	18,3	16,7	15,0	13,4	11,9	10,4	8,8	7,3	5,8	4,4	2,9	1,4		46
46	21,1	19,4	17,7	16,1	14,5	13,0	11,5	10,0	8,5	7,1	5,6	4,2	2,8	1,4		44
48	20,4	18,7	17,1	15,5	14,0	12,5	11,0	9,6	8,2	6,8	5,4	4,1	2,7	1,3		42
50	19,6	18,0	16,4	14,9	13,4	12,0	10,6	9,3	7,9	6,6	5,2	3,9	2,6	1,3		40
52	18,8	17,2	15,7	14,3	12,9	11,4	10,2	8,9	7,6	6,3	5,0	3,8	2,5	1,2		38
54	17,9	16,5	15,0	13,6	12,3	11,0	9,7	8,5	7,2	6,0	4,8	3,6	2,3	1,2		36
56	17,1	15,7	14,3	13,0	11,7	10,5	9,2	8,0	6,9	5,7	4,5	3,4	2,2	1,1		34
58	16,2	14,8	13,5	12,3	11,1	9,9	8,7	7,6	6,5	5,4	4,3	3,2	2,1	1,1		32
60	15,2	14,0	12,7	11,6	10,4	9,3	8,2	7,2	6,1	5,1	4,0	3,0	2,0	1,0		30
62	14,3	13,1	12,0	10,9	9,8	8,8	7,7	6,8	5,8	4,8	3,8	2,9	1,9	0,9		28
64	13,4	12,3	11,2	10,2	9,2	8,2	7,2	6,3	5,4	4,5	3,5	2,7	1,7	0,9		26
66	12,4	11,4	10,4	9,4	8,5	7,6	6,7	5,9	5,0	4,1	3,3	2,5	1,6	0,8		24
68	11,4	10,5	9,5	8,7	7,8	7,0	6,2	5,4	4,6	3,8	3,0	2,3	1,5	0,7		22
70	10,5	9,6	8,7	7,9	7,1	6,4	5,6	4,9	4,2	3,5	2,8	2,1	1,4	0,7		20
72	9,4	8,6	7,9	7,2	6,5	5,6	5,1	4,4	3,8	3,1	2,5	1,9	1,2	0,6		18
74	8,4	7,7	7,0	6,4	5,8	5,1	4,5	4,0	3,4	2,8	2,2	1,7	1,1	0,5		16
76	7,4	6,8	6,2	5,6	5,1	4,5	4,0	3,5	3,0	2,5	2,0	1,5	1,0	0,5		14
78	6,3	5,8	5,3	4,8	4,3	3,9	3,4	3,0	2,6	2,1	1,7	1,3	0,8	0,4		12
80	5,3	4,9	4,4	4,0	3,6	3,2	2,9	2,5	2,1	1,8	1,4	1,1	0,7	0,3		10
82	4,3	3,9	3,5	3,2	2,9	2,6	2,3	2,0	1,7	1,4	1,1	0,8	0,6	0,3		8
84	3,2	2,9	2,7	2,4	2,2	1,9	1,7	1,5	1,3	1,1	0,8	0,6	0,4	0,2		6
86	2,2	1,9	1,8	1,6	1,5	1,3	1,1	1,0	0,9	0,7	0,6	0,4	0,3	0,1		4
88	1,1	1,0	0,9	0,8	0,7	0,6	0,6	0,5	0,4	0,4	0,3	0,2	0,1	0,1		2
90	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0		0

Refraction in right ascension, × sec^t declination.

This correction is — on the east, and + on the west side of the meridian.

No. II. Table of the Effect of Parallax in North Polar Distance, and A.

The horizontal parallax = 8″,6. This correction is always —.

Angle of the vertical and horary.	DEGREES OF ALTITUDE.										Angle of the vertical and horary.
	0°	10°	20°	30°	40°	50°	60°	70°	80°	90°	
°	″	″	″	″	″	″	″	″	″	″	°
0	8,60	8,47	8,08	7,45	6,59	5,53	4,30	2,94	1,49	0,0	90
10	8,47	8,34	7,96	7,34	6,49	5,45	4,23	2,90	1,47	0,0	80
20	8,08	7,96	7,60	7,00	6,19	5,20	4,04	2,77	1,40	0,0	70
30	7,45	7,34	6,99	6,45	5,71	4,79	3,72	2,55	1,29	0,0	60
40	6,59	6,49	6,18	5,70	5,05	4,23	3,29	2,26	1,15	0,0	50
50	5,53	5,44	5,19	4,79	4,23	3,55	2,76	1,89	0,96	0,0	40
60	4,30	4,23	4,04	3,72	3,30	2,76	2,15	1,47	0,74	0,0	30
70	2,94	2,90	2,77	2,55	2,26	1,89	1,47	1,01	0,51	0,0	20
80	1,49	1,47	1,40	1,29	1,14	0,95	0,75	0,50	0,26	0,0	10

Parallax in right ascension, × sec^t declination.

This correction is + on the east, and — on the west side of the meridian.

No. III. Table of the Effect of Parallax in North Polar Distance, and A.

The horizontal parallax being = 10″. This correction is always —.

Angle of the vertical and horary.	DEGREES OF ALTITUDE.										Angle of the vertical and horary.
	0°	10°	20°	30°	40°	50°	60°	70°	80°	90°	
°	″	″	″	″	″	″	″	″	″	″	°
0	10,00	9,85	9,40	8,66	7,66	6,43	5,00	3,42	1,73	0,0	90
10	9,85	9,70	9,26	8,53	7,54	6,34	4,92	3,37	1,70	0,0	80
20	9,40	9,25	8,83	8,14	7,20	6,04	4,70	3,21	1,63	0,0	70
30	8,66	8,53	8,14	7,51	6,64	5,57	4,33	2,96	1,50	0,0	60
40	7,66	7,54	7,20	6,63	5,87	4,93	3,83	2,62	1,32	0,0	50
50	6,43	6,33	6,04	5,56	4,92	4,13	3,21	2,21	1,11	0,0	40
60	5,00	4,92	4,70	4,33	3,83	3,21	2,50	1,71	0,86	0,0	30
70	3,42	3,37	3,21	2,96	2,62	2,20	1,71	1,17	0,59	0,0	20
80	1,73	1,71	1,63	1,50	1,33	1,11	0,87	0,59	0,30	0,0	10

Parallax in right ascension, × sec^t declination.

This correction is + on the east, and — on the west side of the meridian.

No. IV.

Table of Natural Secants.

Deg.	Nat. sec.	Deg.	Nat. sec.	Deg.	Nat. sec.	Deg.	Nat. sec.	Deg.	Nat. sec.	Deg.	Nat. sec.
1	10002	16	10403	31	11666	46	14396	61	20627	76	41336
2	10006	17	10457	32	11792	47	14663	62	21301	77	44454
3	10014	18	10515	33	11924	48	14945	63	22027	78	48097
4	10024	19	10576	34	12062	49	15243	64	22812	79	52408
5	10038	20	10642	35	12208	50	15557	65	23662	80	57588
6	10055	21	10711	36	12361	51	15890	66	24586	81	63925
7	10075	22	10785	37	12521	52	16243	67	25593	82	71853
8	10098	23	10864	38	12690	53	16626	68	26695	83	82055
9	10124	24	10946	39	12868	54	17013	69	27904	84	95668
10	10154	25	11034	40	13054	55	17434	70	29238	85	114737
11	10187	26	11126	41	13250	56	17883	71	30716	86	143356
12	10223	27	11223	42	13456	57	18361	72	32361	87	191075
13	10263	28	11326	43	13673	58	18871	73	34203	88	286537
14	10306	29	11434	44	13902	59	19416	74	36280	89	572987
15	10353	30	11547	45	14142	60	20000	75	38637	90	Infinite

No. V. Table of the Correction of the Time, shewn by an Equatorial, on Account of Refraction, when the Instrument is not previously adjusted to the true Meridian.

Angle of the vertical with the horary circle.	DEGREES OF ALTITUDE.											
	7°	10°	15°	20°	25°	30°	35°	40°	45°	50°	60°	70°	80°
	Sec.	Sec.	Sec.	Sec.	Sec.	Sec.	Sec.	Sec.	Sec.	Sec.	Sec.	Sec.	Sec.
0													
5	338,	241,	161,3	118,9	94,2	74,9	62,	51,7	43,7	36,8	25,3	16,1	8,
10	169,	120,	80,7	59,4	47,	37,4	31,	25,9	21,9	18,4	12,6	8,1	4,
15	114,	81,	54,3	40,	31,8	25,2	20,9	17,4	14,7	12,4	8,5	5,4	2,7
20	86,	61,	41,	30,4	24,1	19,1	15,8	13,2	11,2	9,4	6,5	4,1	2,1
25	70,	50,	33,4	24,6	19,5	15,5	12,8	10,7	9,1	7,6	5,2	3,3	1,7
30	59,	42,	28,2	20,6	16,4	13,	10,8	9,	7,6	6,4	4,4	2,8	1,4
35	51,	36,	24,4	18,	14,3	11,4	9,4	7,8	6,6	5,6	3,8	2,4	1,2
40	46,	33,	21,8	16,	12,7	10,1	8,4	7,	5,9	5,	3,4	2,2	1,1
45	41,	30,	19,9	14,6	11,8	9,2	7,6	6,3	5,4	4,5	3,1	2,	1,
50	38,	27,	18,3	13,4	10,7	8,5	7,1	5,9	5,	4,2	2,9	1,8	0,
55	36,	26,	17,1	12,6	10,1	7,9	6,6	5,5	4,6	3,9	2,7	1,7	0,9
60	34,	24,	16,2	11,9	9,5	7,5	6,3	5,2	4,4	3,7	2,5	1,6	0,8
65	32,	23,	15,5	11,4	9,1	7,2	6,	4,9	4,2	3,5	2,4	1,5	0,8
70	31,	22,	14,9	11,	8,8	6,9	5,8	4,8	4,	3,4	2,3	1,5	0,7
80	30,	21,	14,2	10,5	8,3	6,6	5,5	4,6	3,9	3,2	2,2	1,4	0,7
90	29,	21,	14,	10,3	8,2	6,5	5,4	4,5	3,8	3,2	2,2	1,4	0,7

× Secant of declination.

This equation is — on the east, and + on the west side of the meridian.

No. VI. Table shewing the Correction of the Meridian Line, found by an Equatorial, arising from the Effect of Refraction, in Minutes and Decimals.

Angle of the vertical with the horary circle.	DEGREES OF ALTITUDE.												
	7°	10°	15°	20°	25°	30°	35°	40°	45°	50°	60°	70°	80°
	′	′	′	′	′	′	′	′	′	′	′	′	′
0	84,5	60,3	40,	29,8	22,9	18,3	15,5	12,6	10,9	9,2	6,3	4,	2,3
5	41,7	29,7	19,8	14,8	11,4	9,1	7,7	6,2	5,4	4,5	3,1	2,	1,1
10	27,3	19,5	13,1	9,7	7,5	5,9	5,	4,1	3,5	3,	2,	1,3	0,7
15	20,1	14,4	9,6	7,2	5,5	4,4	3,7	3,	2,6	2,2	1,5	1,	0,5
20	15,8	11,4	7,6	5,6	4,3	3,4	2,9	2,4	2,	1,7	1,2	0,8	0,4
25	12,7	9,1	6,1	4,5	3,4	2,8	2,3	1,9	1,6	1,4	0,9	0,6	0,3
30	10,2	7,5	5,	3,7	2,8	2,3	1,9	1,6	1,3	1,1	0,8	0,5	0,3
35	8,7	6,2	4,2	3,1	2,4	1,9	1,6	1,3	1,1	0,9	0,6	0,4	0,2
40	7,3	5,2	3,5	2,6	2,	1,6	1,3	1,1	0,9	0,8	0,5	0,3	0,2
45	6,1	4,4	2,9	2,2	1,7	1,3	1,1	0,9	0,8	0,6	0,4	0,3	0,2
50	5,1	3,7	2,4	1,8	1,4	1,1	0,9	0,8	0,7	0,5	0,4	0,2	0,1
55	4,2	3,	2,	1,5	1,1	0,9	0,8	0,6	0,5	0,4	0,3	0,2	0,1
60	3,4	2,4	1,6	1,2	0,9	0,8	0,6	0,5	0,4	0,3	0,2	0,2	0,1
65	2,7	1,9	1,3	0,9	0,7	0,6	0,5	0,4	0,3	0,3	0,2	0,1	0,1
70	1,3	0,9	0,6	0,5	0,4	0,3	0,2	0,2	0,2	0,1	0,1	0,1	0,
80	0,0	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,
90													

× Secant of the altitude.

Note. If the observation is on the {east / west} side of the meridian, then is the true meridian so many minutes to the {west / east} of that found by the instrument.

No. VII. Table of the Effect of Refraction in Right Ascension in Time, when the Equatorial is adjusted to the Meridian.

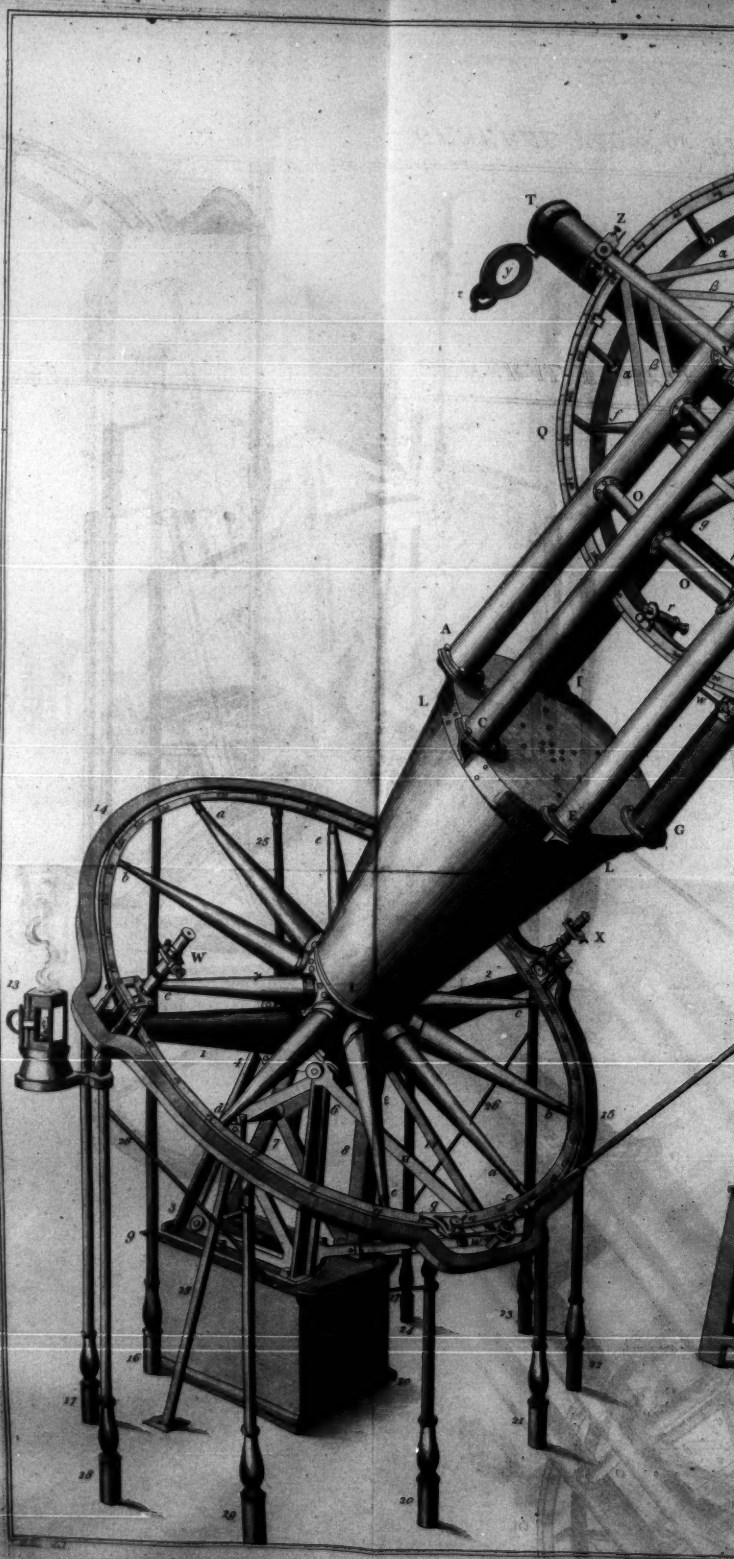
Angle of the vertical with the horary circle.	DEGREES OF ALTITUDE.													
	3° Sec.	5° Sec.	7° Sec.	10° Sec.	15° Sec.	20° Sec.	25° Sec.	30° Sec.	35° Sec.	40° Sec.	45° Sec.	50° Sec.	60° Sec.	70° Sec.	80° Sec.
0															
5	5,1	3,5	2,5	1,8	1,2	0,9	0,7	0,6	0,5	0,4	0,3	0,3	0,2	0,1	0,1
10	10,1	6,9	5,1	3,7	2,5	1,8	1,4	1,1	0,9	0,8	0,7	0,5	0,4	0,3	0,1
15	15,	10,3	7,6	5,4	3,6	2,7	2,1	1,7	1,4	1,2	1,	0,8	0,6	0,4	0,2
20	19,9	13,5	10,	7,2	4,8	3,5	2,8	2,2	1,9	1,4	1,2	1,1	0,7	0,5	0,2
25	24,5	16,6	12,3	8,8	5,9	4,3	3,4	2,7	2,3	1,9	1,6	1,3	0,9	0,6	0,3
30	29,	19,7	14,6	10,5	7,	5,2	4,1	3,3	2,7	2,3	1,9	1,7	1,1	0,7	0,3
35	33,4	22,7	16,8	12,	8,	5,9	4,7	3,7	3,1	2,6	2,2	1,8	1,3	0,8	0,4
40	37,4	25,4	18,6	13,5	9,	6,7	5,2	4,2	3,4	2,9	2,4	2,1	1,4	0,9	0,4
45	41,3	28,	20,7	14,9	9,9	7,3	5,7	4,6	3,9	3,2	2,7	2,3	1,5	1,	0,5
50	44,7	30,3	22,5	16,1	10,7	7,9	6,2	5,	4,1	3,5	2,9	2,5	1,7	1,1	0,5
55	47,7	32,4	24,	17,2	11,5	8,5	6,7	5,3	4,4	3,7	3,1	2,7	1,8	1,1	0,5
60	50,3	34,2	25,3	18,1	12,1	8,9	7,	5,7	4,7	3,9	3,3	2,8	1,9	1,2	0,6
65	52,8	35,9	26,5	19,	12,8	9,3	7,4	5,9	4,9	4,2	3,5	2,9	2,	1,3	0,6
70	54,6	37,	27,5	19,7	13,1	9,7	7,7	6,1	5,1	4,3	3,5	3,	2,1	1,3	0,6
80	57,6	39,1	28,9	20,7	13,8	10,1	8,	6,5	5,3	4,5	3,8	3,2	2,2	1,4	0,7
90	58,4	39,6	29,3	21,	14,	10,3	8,2	6,5	5,4	4,5	3,8	3,2	2,2	1,4	0,7

× Secant of declination.

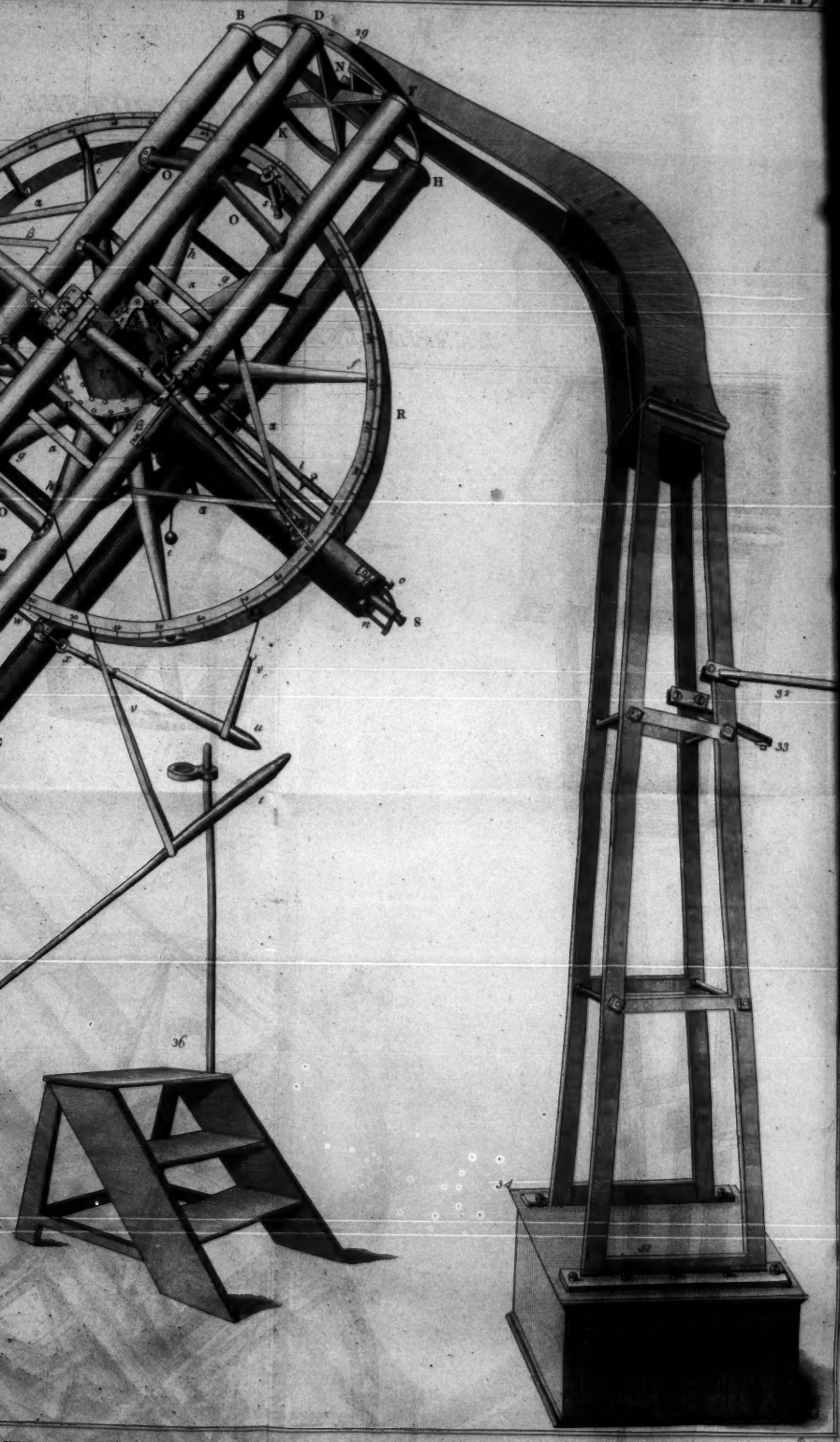
This correction is — on the east, and + on the west side of the meridian.

No. VIII. Table of the Effect of Refraction in Declination, when the Equatorial is adjusted to the Meridian.

Angle of the vertical with the horary circle.	DEGREES OF ALTITUDE.														
	3°	5°	7°	10°	15°	20°	25°	30°	35°	40°	45°	50°	60°	70°	80°
°	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	″	″	″	″
0	14 36	9 54	7 20	5 15	3 30	2 35	2 2	1 38	1 21	1 8	57	48	33	21	10
10	14 24	9 46	7 14	5 11	3 27	2 32	2	1 37	1 20	1 7	57	48	33	21	10
20	13 39	9 16	6 52	4 56	3 17	2 26	1 55	1 32	1 16	1 4	53	45	31	20	9
25	13 12	8 59	6 38	4 45	3 10	2 20	1 50	1 29	1 14	1 2	52	44	30	19	9
30	12 35	8 33	6 20	4 32	3 1	2 14	1 45	1 25	1 10	59	49	42	29	18	9
35	11 55	8 6	6	4 18	2 52	2 7	1 40	1 20	1 6	56	46	39	27	17	8
40	11 11	7 35	5 37	4 1	2 40	1 59	1 33	1 15	1 2	52	43	37	25	16	8
45	10 19	7	5 11	3 43	2 28	1 50	1 26	1 9	58	48	40	34	23	15	7
50	9 22	6 21	4 42	3 22	2 15	1 40	1 18	1 3	52	44	36	31	21	14	6
55	8 21	5 40	4 12	3	2	1 29	1 10	56	46	39	33	27	19	12	6
60	7 16	4 56	3 39	2 37	1 45	1 18	1 1	49	40	34	29	24	16	11	5
65	6 7	4 9	3 4	2 12	1 28	1 5	51	41	34	28	24	20	14	9	4
70	4 58	3 22	2 30	1 48	1 12	53	42	33	28	23	19	16	11	7	3
75	3 45	2 34	1 54	1 21	54	40	32	25	21	18	15	12	9	6	3
80	2 32	1 43	1 16	55	37	27	21	17	14	12	10	8	6	4	2
85	1 16	52	38	27	18	13	11	9	7	6	5	4	3	2	1



GENERAL VIEW OF THE



THE EQUATORIAL INSTRUMENT.

One third the size of the Original.

Fig. 1.

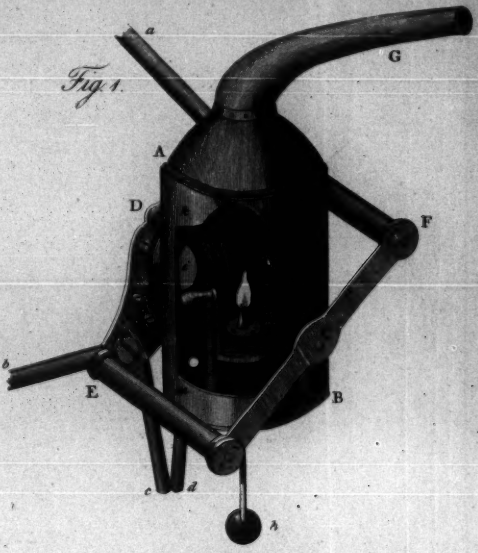
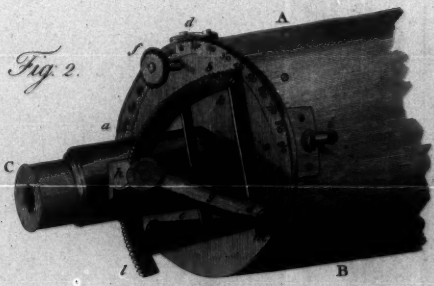
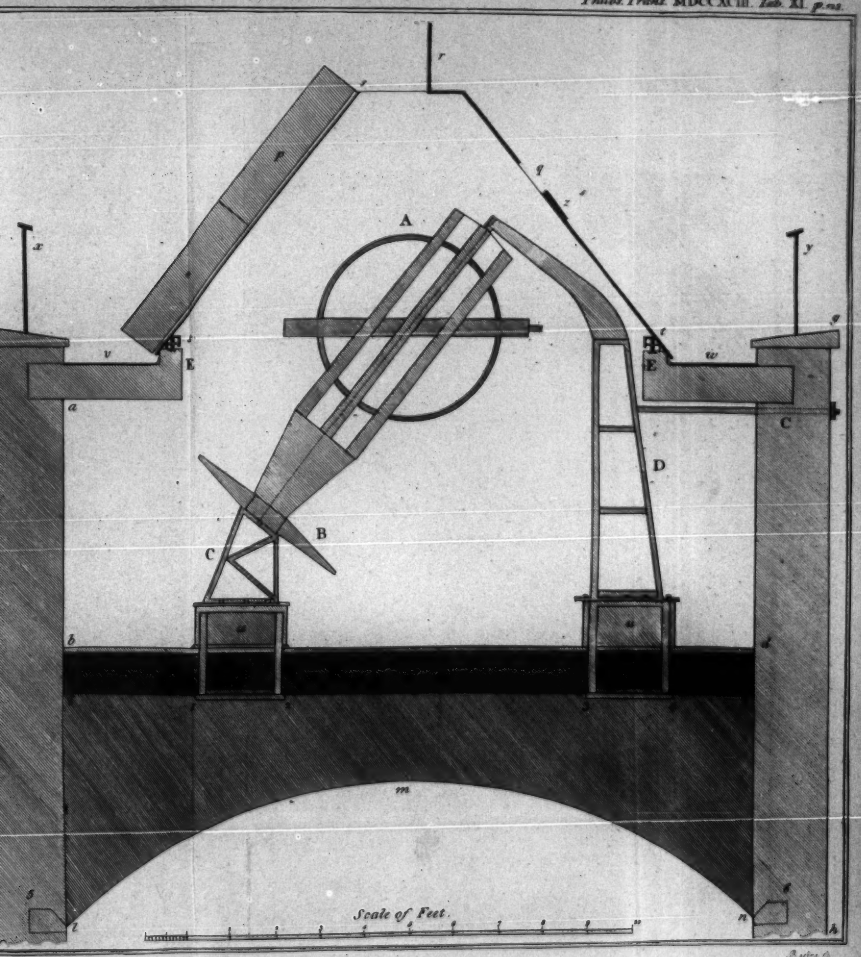


Fig. 3.

One half the size of the Original

Fig. 2.

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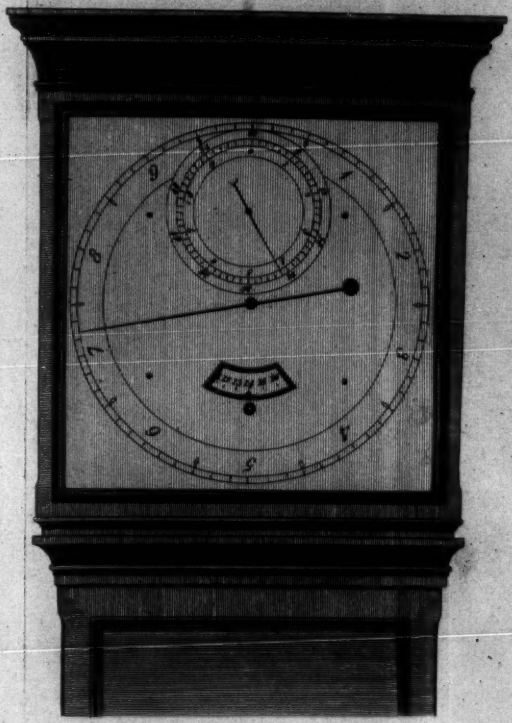
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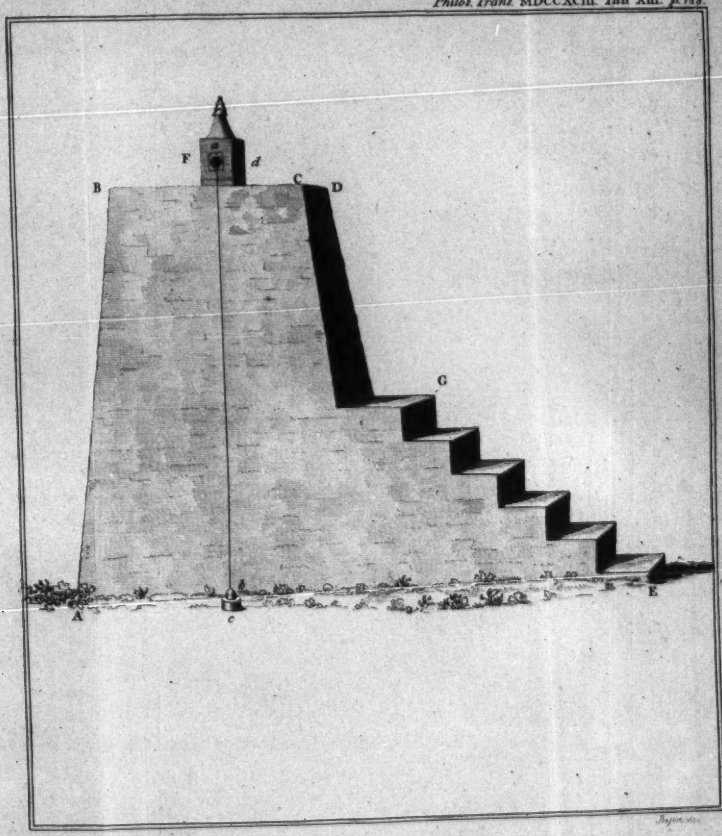
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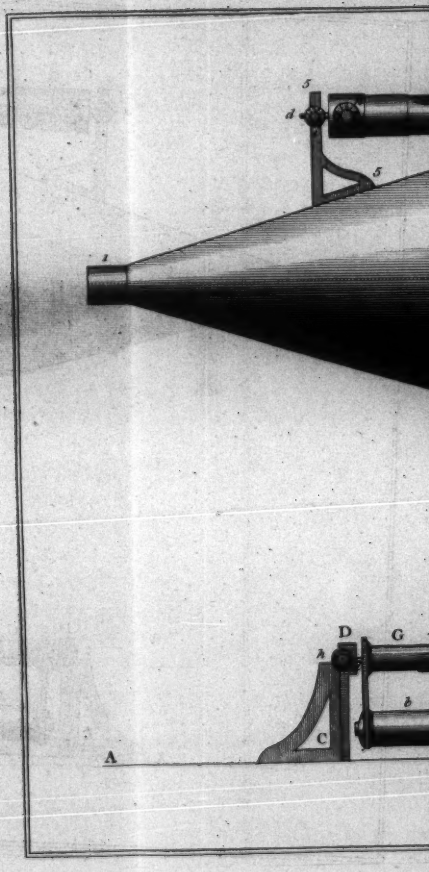
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Fig. 1. ⅓ of the original size.

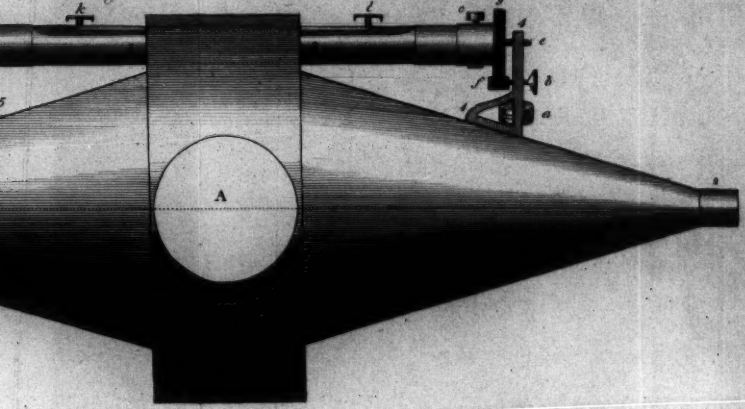

Fig. 2. ⅓ of the original size.

XI. *Additional Observations on the Method of making Ice at* Benares. *In a Letter to* William Marsden, *Esq. F. R. S. from* John Lloyd Williams, *Esq. of* Benares.

Read May 2, 1793.

DEAR SIR,

In addition to what I have already communicated to you, respecting the mode of procuring ice in this country, the following observations on that subject, accompanied with some account of the temperature of the air, and state of the thermometer, may not be unacceptable.

April 30th, 1792, the thermometer, in the shade, being at 95 degrees, some water was taken up from a well, sixty feet deep, and the thermometer being immerged in it, its temperature was found to be 74 degrees. This water was then poured into four pots, or pans, similar to those which, in my former letter, I mentioned as being employed in the process for making ice. They were also similar to each other in size and construction, except that two of them were new and unglazed, and the two others old, with their pores closed, so that no moisture could transpire through them. These pots were then exposed to a hot westerly wind, in the shade, for the space of three hours; viz. from two o'clock in the afternoon till five. Upon examining them at that time, the water in

the old pots was found to be at 84 degrees, and that in the new, or porous ones, at 68. After remaining in that situation one hour longer, the water in the old pots rose to 88 degrees, whilst that in the new ones continued at 68.

May 1st, at two o'clock in the afternoon, the thermometer then being, in the sun, at 110 degrees, and in the shade at 100, the experiment was repeated, with the same pots as before. After being filled with well-water, they were exposed for four hours, viz. from two o'clock till six, to a hot wind; the water in the old pots was then found to be at 97 degrees, that in the new ones at 68.

The foregoing observations on the frigorific effect of evaporation from porous vessels, will perhaps account, in some measure, for ice being formed when the thermometer, in the air, is above the freezing point. And the power of evaporation in generating cold, may be further elucidated by the following observations on the effects produced, by its means, in our houses.

May 16, 1792, at two in the afternoon,

The thermometer, in the sun, with a hot westerly wind, rose to - - - -	118 degrees.
Ditto, in the shade, but exposed to the hot wind - - - -	110 ditto.
Ditto, in the house, which was kept cool by *tatties* - - - -	87 ditto.

June 7.

Thermometer, in the sun - - -	113 degrees.
Ditto, in the shade, and hot wind -	104 ditto.
Ditto, in the house, cooled by *tatties* -	83 ditto.

Tatties are a kind of mat, made of fresh green bushes, or long roots, like snake-root; they are affixed to the door or window frames, and kept constantly sprinkled with water. The degree of cold produced by their means is supposed to be in proportion to the heat of the wind which passes through them, as on that depends the quantity of evaporation.

I am, &c.

Benares,
October 1, 1792.

J. LL. WILLIAMS.

METEOROLOGICAL JOURNAL,

KEPT AT THE APARTMENTS

OF THE

ROYAL SOCIETY,

BY ORDER OF THE

PRESIDENT AND COUNCIL.

METEOROLOGICAL JOURNAL

for January, 1792.

1792	Time. H.	Time. M.	Therm. without. °	Therm. within. °	Barom. Inches.	Hygrometer *	Rain. Inches.	Winds. Points.	Winds. Str.	Weather.
Jan. 1	8	0	44	53	29,34	80	0,105	SSE	1	Cloudy.
	2	0	44	57,5	29,38	78		E	1	Cloudy.
2	8	0	41	52	29,87	83	0,125	NE	1	Rain.
	2	0	43,5	55	29,95	74		NNE	2	Cloudy.
3	8	0	36,5	52	30,14	73		N	1	Cloudy.
	2	0	43	55	30,14	73		NE	1	Cloudy.
4	8	0	38	52	30,35	77		NNE	1	Cloudy.
	2	0	42	55,5	30,38	73		NNE	1	Cloudy.
5	8	0	38	52	30,47	77		N	1	Cloudy.
	2	0	39,5	54,5	30,46	71		NNW	1	Cloudy.
6	8	0	35	52	30,42	75		NNE	1	Cloudy.
	2	0	38,5	54,5	30,33	70		NNE	1	Cloudy.
7	8	0	40	51,5	30,11	77		W	1	Cloudy.
	2	0	44	55	30,00	72		WNW	1	Cloudy.
8	8	0	31	50	30,15	69		NE	1	Cloudy.
	2	0	36	54,5	30,18	65		NE	1	Fine.
9	8	0	33	50	29,80	70		WNW	1	Cloudy.
	2	0	38	53,5	29,55	75		WNW	1	Cloudy.
10	8	0	34,5	50	29,36	73	0,060	WNW	1	Cloudy.
	2	0	36	53,5	29,36	75		E	1	Cloudy.
11	8	0	25	46	29,27	68		NE	1	Fair.
	2	0	29	48	29,21	60		NE	1	Fine.
12	8	0	19	44	29,21	67		WNW	1	Fine.
	2	0	28	46,5	29,25	65		WNW	1	Fine.
13	8	0	20	44	29,64	69		WNW	1	Hazy.
	2	0	28	45,5	29,71	63		WNW	1	Fine.
14	8	0	24	43	29,67	70		E	2	Fine.
	2	0	30	44,5	29,44	64		E	2	Cloudy.
15	8	0	40	44,5	29,06	92	0,040	S	2	Rain.
	2	0	43	48	28,98	85		SSE	2	Cloudy.
16	8	0	41	46,5	29,11	82	0,015	S	2	Cloudy.
	2	0	43	49,5	29,13	81		S	2	Rain.

* These observations were made with Mr. De Luc's hygrometer, described in Vol. LXXXI. of the Phil. Trans. p. 420.

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for January, 1792.

1792	Time. H.	Time. M.	Therm. without. °	Therm. within. °	Barom. Inches.	Hygrometer.	Rain. Inches.	Winds. Points.	Winds. Str.	Weather.
Jan. 17	8	0	42	48,5	29,25	*	0,074	ENE	1	Foggy.
	2	0	45	52	29,42			NNE	1	Cloudy.
18	8	0	34	48,5	29,88			NE	1	Fair.
	2	0	37	51,5	29,92			NE	1	Fair.
19	8	0	32	48	30,00			NE	1	Cloudy.
	2	0	36	49,5	30,00			ENE	1	Cloudy.
20	8	0	33	48	30,04			ENE	1	Cloudy.
	2	0	34	48	29,96			E	1	Cloudy.
21	8	0	32	47	29,80		*	E	1	Cloudy.
	2	0	36	49	29,83			E	1	Cloudy.
22	8	0	35	48	29,85			E	1	Foggy.
	2	0	40	50	29,75			E	1	Cloudy.
23	8	0	33	47	29,47		0,268	WNW	1	Cloudy.
	2	0	36,5	50	29,56			WNW	1	Cloudy.
24	8	0	42	48	29,57		0,055	SSW	1	Foggy.
	2	0	47	51	29,46			S	2	Cloudy.
25	8	0	47	51	29,20		0,340	SW	2	Cloudy; much wind
	2	0	51	55	29,32			SW	2	Cloudy. [last night.
26	8	0	48	52,5	29,01		0,145	SW	2	Cloudy; much wind
	2	0	50	54,5	28,94			SW	2	Cloudy. [last night.
27	8	0	46	53,5	29,48		0,130	WSW	1	Cloudy.
	2	0	50	57,5	29,57			W	2	Cloudy.
28	8	0	42	53	29,52			E	1	Cloudy.
	2	0	48	57	29,35			SW	1	Rain.
29	8	0	46	55	29,55		0,195	SSW	1	Cloudy.
	2	0	48	57	29,46			SSW	1	Cloudy.
30	8	0	43	55	29,75		0,120	SW	1	Cloudy.
	2	0	50	57	29,74			SW	2	Cloudy.
31	8	0	48	55	29,52			SW	1	Fair.
	2	0	53	57,5	29,53		0,138	SW	2	Fine.

* This interruption, in the observations of the hygrometer, was occasioned by one end of the whalebone having slipped out of the pincers by which it is held.

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for February, 1792.

1792	Time. H.	Time. M.	Therm. without. °	Therm. within. °	Barom. Inches.	Hygrometer.	Rain. Inches.	Winds. Points.	Winds. Str.	Weather.
Feb. 1	8	0	47	56	29,66			SW	1	Fair.
	2	0	52	58	29,80			WNW	1	Fair.
2	8	0	50	56	29,90			SW	2	Cloudy.
	2	0	52,5	58	29,84			SW	2	Cloudy.
3	8	0	40	56	30,05			W	1	Fine.
	2	0	47	57	30,10			W	2	Cloudy.
4	8	0	35	55	30,29			W	1	Fair.
	2	0	43	58,5	30,29			NW	1	Fine.
5	8	0	37	54	30,17			E	1	Foggy.
	2	0	43	55	30,13			ESE	1	Fair.
6	8	0	37	53	30,00			E	1	Cloudy.
	2	0	45	55	29,95			SSW	1	Cloudy.
7	8	0	48	53,5	29,75		0,095	SW	2	Cloudy.
	2	0	51,5	56,5	29,70			SW	2	Cloudy.
8	8	0	43	54	29,67		0,295	WSW	1	Fair.
	2	0	49,5	57	29,83			WSW	1	Fair.
9	8	0	40	55	30,30			N	1	Fair.
	2	0	43	56,5	30,40			W	1	Cloudy.
10	8	0	43	54,5	30,40			SW	1	Cloudy.
	2	0	48	57	30,36			WSW	1	Cloudy.
11	8	0	44	55	30,18			SWbyW	1	Cloudy.
	2	0	50	58	30,16			WSW	1	Cloudy.
12	8	0	46	56	30,16			WSW	1	Fair.
	2	0	56	58,5	30,18			WSW	1	Fine.
13	8	0	41	57	30,26			WSW	1	Fine.
	2	0	52	60	30,26			WSW	1	Fine.
14	8	0	37	56	30,22			WNW	1	Fair.
	2	0	44	58	30,22			WNW	1	Hazy.
15	8	0	37	55	30,06			W	1	Foggy.
	2	0	45	57,5	30,04			E	1	Fair.
16	8	0	36	54	30,17			NE	1	Cloudy.
	2	0	38	56	30,22			NE	1	Cloudy.

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1792	Time. H.	Time. M.	Therm. without.	Therm. within.	Barom.	Hygrometer.	Rain.	Winds. Points.	Winds. Str.	Weather.
			o	o	Inches.		Inches.			
Feb. 17	8	o	26	51	30,40			NNE	2	Fair.
	2	o	32	53	30,28			NE	2	Fair.
18	8	o	23	47	29,98			NNE	2	Fair.
	2	o	26,5	49,5	30,00			NNE	2	Fine.
19	8	o	30	46,5	29,70			NNE	2	Cloudy.
	2	o	32	48,5	29,62			E	1	Snow.
20	8	o	22,5	44	29,53			NE	1	Snow.
	2	o	26	47	29,03	49		NNW	1	Fine.
21	8	o	16,5	43	29,78	59		WNW	1	Hazy.
	2	o	29	46	29,77	52		W	1	Fair.
22	8	o	31	43,5	29,59	73		NW	1	Hazy.
	2	o	34,5	48	29,72	59		WNW	1	Fair.
23	8	o	27	44	29,88	67		W	1	Hazy.
	2	o	33	48	29,93	60		E	1	Fine.
24	8	o	30	44,5	29,86	65		E	1	Cloudy.
	2	o	37	47	29,80	61		E	1	Rain.
25	8	o	38,5	46	29,84	90	0,120	E	1	Cloudy.
	2	o	41,5	47,5	29,77	87		E	1	Cloudy.
26	8	o	43,5	48	29,61	90	0,202	SE	1	Cloudy.
	2	o	51	51	29,64	79		SSW	2	Cloudy.
27	8	o	42	49	29,89	86		SW	2	Fine.
	2	o	49	52,5	29,94	68		SW	1	Cloudy.
28	8	o	40	50	30,02	82		ENE	1	Cloudy.
	2	o	49	53	30,04	64		ESE	1	Hazy.
29	8	o	40	52	29,99	74		E	1	Cloudy.
	2	o	47	54	29,95	71		SE	1	Cloudy.

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1792	Time. H.	Time. M.	Therm. without.	Therm. within.	Barom.	Hygrometer.	Rain.	Winds. Points.	Winds. Str.	Weather.
			o	o	Inches.		Inches.			
Mar. 1	7	o	43	52	29,80	85		E	1	Foggy.
	2	o	50	55	29,66	64		ESE	2	Cloudy.
2	7	o	47	52,5	29,45	76		E	1	Cloudy.
	2	o	51	56	29,45	79		S	1	Rain.
3	7	o	43	55	29,58	84	0,050	SSW	1	Cloudy.
	2	o	50	57	29,57	64		SSW	2	Cloudy.
4	7	o	48	54	29,14	79	0,091	S	2	Rain.
	2	o	50	57	29,07	77		SSW	2	Cloudy.
5	7	o	45	55	29,40	77	0,510	SW	1	Cloudy.
	2	o	46	56	29,58	63		WNW	1	Cloudy.
6	7	o	41	53	29,44	75		S	2	Rain.
	2	o	48	53	29,37	53		WSW	2	Fine.
7	7	o	37	53,5	29,44	70	0,129	W	1	Fine.
	2	o	40	55	29,50	67		WSW	1	Rain.
8	7	o	34	52	29,57	63	0,231	WNW	1	Fair.
	2	o	40	54	29,64	55		NW	1	Cloudy.
9	7	o	26	50	29,91	64		NNE	1	Fair.
	2	o	33	52	29,98	55		NNE	1	Cloudy.
10	7	o	26	48,5	30,13	65		NNE	1	Fine.
	2	o	34	48	30,18	54		NNE	1	Fine.
11	7	o	28	46,5	30,26	64		NNE	1	Fine.
	2	o	36	48,5	30,31	51		NNE	1	Fair.
12	7	o	29	47	30,49	63		ENE	1	Fair.
	2	o	36	51	30,51	51		E	1	Fine.
13	7	o	30	46	30,23	61		E	1	Cloudy.
	2	o	40	48,5	29,91	53		SE	1	Cloudy.
14	7	o	41	47	29,58	80	0,067	SW	1	Cloudy.
	2	o	49	51	29,54	57		WSW	1	Cloudy.
15	7	o	43	49	29,41	78	0,134	WNW	1	Fair.
	2	o	47	52	29,40	61		W	1	Cloudy.
16	7	o	38	50	29,86	76		W	1	Fair.
	2	o	51	54	29,93	65		W	1	Fair.

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1792	Time. H.	M.	Therm. without.	Therm. within.	Barom.	Hygrometer.	Rain.	Winds. Points.	Str.	Weather.
			o	o	Inches.		Inches.			
Mar. 17	7	o	47	54	29,83	79		SW	2	Cloudy.
	2	o	52	56	29,82	74		SW	2	Cloudy.
18	7	o	49	54	29,66	70		SW	2	Cloudy.
	2	o	53,5	57	29,75	57		SW	2	Fair.
19	7	o	38	53,5	30,12	70	0,034	W	1	Fine.
	2	o	50	58	30,19	48		W	1	Fine.
20	7	o	42	53,5	30,19	65		S	2	Fine.
	2	o	50	57	30,12	49		S by W	2	Fine.
21	7	o	43	54	30,08	76	0,041	SW	1	Cloudy.
	2	o	53	57,5	30,11	53		WNW	1	Cloudy.
22	7	o	43	54,5	30,08	56		WNW	1	Cloudy.
	2	o	51	57,5	30,05	57		NW	1	Fair.
23	7	o	43	55	29,87	61		SW	2	Cloudy.
	2	o	53,5	58	29,82	54		WSW	2	Fair.
24	7	o	47,5	57	29,80	65		SSW	2	Cloudy.
	2	o	50	57,5	29,69	68		SSW	2	Cloudy.
25	7	o	51	57	29,50	76	0,074	SW	2	Cloudy.
	2	o	54,5	59	29,56	50		SW	2	Cloudy.
26	7	o	47	56,5	29,60	66	0,055	SW	2	Fair.
	2	o	52	58,5	29,58	52		W	2	Cloudy.
27	7	o	44	56	29,48	70	0,103	SSW	2	Cloudy.
	2	o	49,5	58,5	29,49	62		SW	2	Fair.
28	7	o	43	56	29,74	65	0,082	W	1	Fine.
	2	o	52	59	29,84	52		SW	1	Cloudy.
29	7	o	47	57	29,70	60		SSE	2	Fine.
	2	o	56	61	29,61	50		SSE	2	Fine.
30	7	o	44	58	29,66	67	0,140	WSW	1	Cloudy.
	2	o	46	59,5	29,72	65		S	2	Cloudy.
31	7	o	42	57	30,00	65	0,050	W	1	Fair.
	2	o	52	60	29,98	60		SW	2	Cloudy.

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1792	Time. H.	Time. M.	Therm. without.	Therm. within.	Barom.	Hygrometer.	Rain.	Winds. Points.	Winds. Str.	Weather.
			o	o	Inches.		Inches.			
Apr. 1	7	0	52	57,5	29,70	75	0,039	SW	2	Cloudy.
	2	0	54	60,5	29,65	70		SW	2	Cloudy.
2	7	0	48	58	29,59	66		WSW	2	Cloudy.
	2	0	52,5	60	29,64	64		SW	2	Cloudy.
3	7	0	39,5	57,5	29,86	67	0,048	W	1	Fair.
	2	0	50	58	29,80	51		SW by S	2	Cloudy.
4	7	0	48	57	29,43	69	0,205	W	1	Fine.
	2	0	55	59	29,38	65		WNW	2	Cloudy.
5	7	0	42	57	29,42	65	0,117	WNW	1	Fine.
	2	0	52	58,5	29,50	52		WNW	2	Fair.
6	7	0	43	56,5	29,94	63		NW	1	Cloudy.
	2	0	52	59	30,13	51		NW	2	Fair.
7	7	0	42,5	57,5	30,30	62		WNW	1	Fine.
	2	0	53	60,5	30,32	45		S	2	Fine.
8	7	0	48	57	30,22	51		SSE	1	Hazy.
	2	0	55	61	30,16	45		SE	1	Fair.
9	7	0	47	59	30,07	60		E	1	Fair.
	2	0	57	60,5	30,05	53		E	1	Hazy.
10	7	0	52	60	30,00	61		ENE	1	Fair.
	2	0	60,5	63	29,98	44		E	1	Fine.
11	7	0	49,5	60,5	30,01	61		ENE	1	Fine.
	2	0	63	65,5	30,00	44		E	1	Fine.
12	7	0	52	62	30,05	62		E	1	Fine.
	2	0	62	64	30,02	54		SE	1	Fair.
13	7	0	57	63	29,98	59		E	1	Cloudy.
	2	0	66	64,5	29,98	61		W	1	Fair.
14	7	0	55	63	30,01	60		W	1	Cloudy.
	2	0	61,5	63,5	30,01	59		W	1	Hazy.
15	7	0	52	62	29,98	61		ENE	2	Cloudy.
	2	0	57	61,5	29,94	56		ENE	2	Hazy.
16	7	0	48	60	29,93	61		ENE	2	Fair.
	2	0	56,5	61	29,89	56		ENE	2	Fair.

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1792	Time. H.	Time. M.	Therm. without. °	Therm. within. °	Barom. Inches.	Hygrometer.	Rain. Inches.	Winds. Points.	Winds. Str.	Weather.
Apr. 17	7	0	52	60	29,70	56		ENE	2	Cloudy.
	2	0	53	59	29,62	62		E	1	Cloudy.
18	7	0	47	58,5	29,26	70	0,251	WNW	1	Rain.
	2	0	48	60	29,12	67		WNW	1	Cloudy.
19	7	0	41	57	29,21	70	0,552	NW	1	Rain.
	2	0	42,5	57	29,33	70		N	2	Rain.
20	7	0	38	56	29,87	66	0,150	N	1	Fine.
	2	0	44,5	55,5	30,07	55		N	2	Cloudy.
21	7	0	42	55	30,23	60		W	2	Cloudy.
	2	0	51,5	57	30,22	50		SW	2	Fair.
22	7	0	48	54,5	30,04	65		SW	2	Cloudy.
	2	0	55	57,5	30,03	59		SW	2	Cloudy.
23	7	0	49	56,5	29,82	59		SW	2	Fine.
	2	0	60,5	59,5	29,77	47		SSW	2	Fine.
24	7	0	51,5	58	29,72	65		NE	1	Cloudy.
	2	0	52,5	59,5	29,73	66		NW	1	Cloudy.
25	7	0	43,5	58	29,89	67	0,188	W	1	Fine.
	2	0	55,5	60	29,96	47		W	1	Fine.
26	7	0	46	58	30,17	66		W	1	Fair.
	2	0	58,5	60,5	30,17	47		W	1	Fine.
27	7	0	52	59	30,15	61		SW	2	Cloudy.
	2	0	57	61,5	30,18	59		SW	2	Cloudy.
28	7	0	54,5	59,5	30,23	65		SW	2	Cloudy.
	2	0	60	60,5	30,28	59		SW	2	Cloudy.
29	7	0	56	60	30,30	63		SW	1	Fair.
	2	0	62	61	30,26	55		NE	1	Fine.
30	7	0	54	60,5	30,01	64		NE	1	Hazy.
	2	0	63	63	29,86	62		NE	1	Fair.

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1792	Time. H.	Time. M.	Therm. without. °	Therm. within. °	Barom. Inches.	Hygrometer.	Rain. Inches.	Winds. Points.	Winds. Str.	Weather.
May 1	7	0	45	59,5	29,93	61	0,070	W	1	Fair.
	2	0	53	59,5	29,99	43		WNW	2	Fair.
2	7	0	46	58,5	30,15	56		WNW	1	Fine.
	2	0	53	59	30,18	44		NW	1	Fair.
3	7	0	42,5	57,5	30,36	55		WNW	1	Fine.
	2	0	52	58	30,32	44		WNW	1	Fine.
4	7	0	49	58	30,06	65		WNW	1	Cloudy.
	2	0	53	58	29,88	65		WNW	2	Cloudy.
5	7	0	43	56	30,14	60	0,105	N	2	Fair.
	2	0	50	56,5	30,13	57		NE	2	Cloudy.
6	7	0	45,5	55,5	30,18	62		NE	2	Fine.
	2	0	55	57	30,16	50		NE	2	Fair.
7	7	0	46,5	54,5	30,06	61		NE	2	Fine.
	2	0	57,5	56,5	30,01	45		NE	2	Fair.
8	7	0	46	56	30,06	60		NE	2	Fine.
	2	0	54,5	58	30,02	53		NE	2	Fine.
9	7	0	47	56,5	30,03	60		NE	2	Cloudy.
	2	0	52,5	56,5	30,05	52		NE	2	Cloudy.
10	7	0	44,5	55,5	30,12	58		NE	1	Cloudy.
	2	0	47,5	54,5	30,13	55		NE	1	Cloudy.
11	7	0	44	54	30,17	55		NE	1	Cloudy.
	2	0	50,5	54	30,16	45		NE	1	Cloudy.
12	7	0	45	54	30,16	54		N	1	Cloudy.
	2	0	52,5	54,5	30,18	47		NW	1	Cloudy.
13	7	0	46	54	30,17	56		WNW	1	Fine.
	2	0	56,5	55,5	30,13	46		WSW	1	Cloudy.
14	7	0	50	55	30,06	62		SW	1	Cloudy.
	2	0	52	56	30,06	63		SW	1	Rain.
15	7	0	51	55,5	30,05	67	0,088	SW	1	Cloudy.
	2	0	61,5	58	30,03	51		SW	2	Fair.
16	7	0	53	57	29,88	64	0,030	SW	1	Fair.
	2	0	55	58	29,79	61		SSW	1	Rain.

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1792	Time. H.	Time. M.	Therm. without. °	Therm. within. °	Barom. Inches.	Hygrometer.	Rain. Inches.	Winds. Points.	Winds. Str.	Weather.
May 17	7	0	50	57,5	29,70	72	0,546	SSW	2	Rain.
	2	0	62	59	29,80	50		WSW	2	Fair.
18	7	0	55	58	29,77	72	0,044	WSW	2	Cloudy.
	2	0	63,5	59,5	29,90	52		W	2	Cloudy.
19	7	0	56	59,5	29,91	64	0,038	SW	2	Fair.
	2	0	66,5	62	29,92	50		SW	2	Fine.
20	7	0	57	61	30,04	64		SW	1	Cloudy.
	2	0	67	63	30,01	52		SW	1	Fair.
21	7	0	58	62	29,76	69	0,253	SE	1	Cloudy.
	2	0	61	63	29,84	61		W	1	Rain.
22	7	0	53	62	30,10	62	0,056	W	1	Fair.
	2	0	61	62,5	30,11	61		W	1	Fair.
23	7	0	47	60,5	30,29	58	0,027	NW	1	Fine.
	2	0	56,5	61	30,31	48		NNE	1	Fair.
24	7	0	48	60	30,39	52		E	1	Fine.
	2	0	56,5	60	30,36	51		E	1	Fine.
25	7	0	52	59	30,05	59		ESE	1	Cloudy.
	2	0	59	60	29,90	51		SSE	1	Cloudy.
26	7	0	53	59	29,72	68	0,098	WSW	2	Cloudy.
	2	0	63	61	29,73	51		WSW	2	Fair.
27	7	0	53	60	29,76	65	0,114	WSW	2	Fair.
	2	0	58,5	60	29,62	53		S	2	Cloudy.
28	7	0	51,5	59	29,40	62	0,091	WSW	2	Fair.
	2	0	55	59	29,37	58		S	2	Cloudy.
29	7	0	52,5	58	29,32	62	0,064	S	2	Cloudy.
	2	0	57	59	29,35	56		S	2	Cloudy.
30	7	0	52	58,5	29,62	63		SSW	2	Fine.
	2	0	62,5	60,5	29,66	50		SSW	2	Fair.
31	7	0	52	59,5	29,93	64		W	1	Fine.
	2	0	64	61	29,99	46		W	1	Fine.

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1792	Time. H.	M.	Therm. without. °	Therm. within. °	Barom. Inches.	Hygrometer.	Rain. Inches.	Winds. Points.	Str.	Weather.
June 1	7	0	53	60,5	30,07	59		S	1	Fine.
	2	0	67	63	30,02	47		SSW	1	Fine.
2	7	0	59	61,5	30,00	07		SW	1	Cloudy.
	2	0	66	63,5	30,18	60		N	1	Fine.
3	7	0	55	61,5	30,24	62		NNE	1	Cloudy.
	2	0	65,5	63	30,24	48		NE	2	Fine.
4	7	0	53	61,5	30,22	59		NE	1	Fair.
	2	0	64	64	30,17	50		NE	2	Fine.
5	7	0	50	61	30,08	65		N	2	Cloudy.
	2	0	62	62	30,02	57		NNE	1	Fair.
6	7	0	51	61	29,93	59		N	1	Cloudy.
	2	0	59,5	61,5	29,93	50		NNE	1	Fair.
7	7	0	52	61	29,91	02		NE	1	Cloudy.
	2	0	60	61	29,87	63		NW	1	Fair.
8	7	0	49	60	29,69	66	0,157	SSE	2	Rain.
	2	0	57	61	29,62	59		S	2	Cloudy.
9	7	0	51	60	29,78	59	0,053	WNW	1	Cloudy.
	2	0	59,5	61	29,76	51		SW	1	Cloudy.
10	7	0	53	60	29,65	60		SW	1	Cloudy.
	2	0	57,5	61	29,55	59		SSW	1	Cloudy.
11	7	0	54	60	29,41	65	0,058	W	1	Fair.
	2	0	61	61	29,48	61		SW	2	Fair.
12	7	0	52	60	29,77	58	0,050	WSW	1	Fine.
	2	0	59	61	29,77	53		W	1	Cloudy.
13	7	0	52	59,5	29,72	62	0,015	SW	1	Cloudy.
	2	0	53	60	29,66	60		SSE	1	Rain.
14	7	0	54	59,5	29,58	69	0,133	WNW	1	Cloudy.
	2	0	59	60,5	29,85	56		NNW	1	Cloudy.
15	7	0	52	60	30,26	60		WNW	1	Fine.
	2	0	66	61,5	30,26	40		WNW	1	Fine.
16	7	0	58	61,5	30,27	56		E	1	Fine.
	2	0	67	63,5	30,26	46		E	1	Fine.

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1792	Time. H.	Time. M.	Therm. without. °	Therm. within. °	Barom. Inches.	Hygrometer.	Rain. Inches.	Winds. Points.	Winds. Str.	Weather.
June 17	7	0	60	62,5	30,01	57		E	1	Fair.
	2	0	72	65	29,96	49		SSW	1	Fair.
18	7	0	55	63,5	29,97	53		WNW	1	Fine.
	2	0	63	64	29,92	49		WNW	1	Fair.
19	7	0	55	63	29,74	57		NW	1	Fair.
	2	0	59	63	29,73	55		NW	2	Cloudy.
20	7	0	50	61,5	29,73	57		NW	1	Cloudy.
	2	0	52,5	62	29,75	66		NW	1	Cloudy.
21	7	0	51,5	60,5	29,80	60	0,072	NW	1	Cloudy.
	2	0	62	61	29,80	47		NW	1	Cloudy.
22	7	0	53	61	29,77	59		W	2	Fair.
	2	0	58,5	61	29,75	57		SW	1	Cloudy.
23	7	0	51	60	29,81	58	0,174	SW	2	Fair.
	2	0	59	60,5	29,80	55		SW	2	Cloudy.
24	7	0	53	60,5	29,88	60	0,051	SSW	2	Cloudy.
	2	0	56	60	29,84	60		S	2	Rain.
25	7	0	52	59,5	30,04	63	0,351	W	1	Cloudy.
	2	0	63	60,5	30,14	51		WNW	1	Cloudy.
26	7	0	55	60,5	30,17	62	0,039	WNW	2	Cloudy.
	2	0	61,5	61	30,18	56		WNW	2	Cloudy.
27	7	0	57	61	30,18	66		SW	1	Cloudy.
	2	0	68	62	30,14	59		SW	1	Cloudy.
28	7	0	58	62	30,18	65		WSW	1	Fair.
	2	0	79,5	64,5	30,15	54		WSW	1	Fair.
29	7	0	63	64,5	30,08	64		W	1	Cloudy.
	2	0	67	65	30,02	64		WSW	1	Rain.
30	7	0	56	64,5	29,88	64	0,471	WNW	1	Fine.
	2	0	63	64,5	29,92	48		WNW	1	Fair.

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1792	Time. H.	Time. M.	Therm. without. °	Therm. within. °	Barom. Inches.	Hygrometer.	Rain. Inches.	Winds. Points.	Winds. Str.	Weather.
July 1	7	0	54	63,5	29,99	55		WNW	1	Fair.
	2	0	63	63,5	29,99	46		NW	1	Fair.
2	7	0	54	63,5	30,00	60		WNW	1	Cloudy.
	2	0	64	64	30,00	52		WNW	1	Cloudy.
3	7	0	56,5	63,5	29,96	57		WNW	1	Cloudy.
	2	0	60,5	64	29,91	53		WNW	1	Cloudy.
4	7	0	57	63	29,80	67		SW	2	Cloudy.
	2	0	64	64	29,80	62		SW	1	Cloudy.
5	7	0	57	64	29,95	61		W	1	Fair.
	2	0	59,5	64	29,85	59		SW	2	Cloudy.
6	7	0	57	64	30,00	57		WNW	1	Fair.
	2	0	60	64	30,02	55		WNW	1	Cloudy.
7	7	0	58	64	30,07	67		WNW	1	Cloudy.
	2	0	72	65	30,02	56		WSW	1	Fair.
8	7	0	58	65	29,94	61		SW	2	Cloudy.
	2	0	72	65	29,96	54		SW	1	Cloudy.
9	7	0	57	65	30,01	64		SW	1	Cloudy.
	2	0	65	65	30,01	61		SSW	1	Cloudy.
10	7	0	61	65	29,93	78	0,296	E	1	Cloudy.
	2	0	68	66	29,94	63		SE	1	Fair.
11	7	0	60	65,5	29,92	76	0,054	NW	1	Cloudy.
	2	0	64	66	29,84	75		NNE	1	Cloudy.
12	7	0	57	65	29,60	76	0,128	NNE	1	Cloudy.
	2	0	61	65	29,59	74		NNE	1	Cloudy.
13	7	0	57,5	65	29,68	79	0,067	WNW	1	Rain.
	2	0	62	64,5	29,78	76		W	1	Cloudy.
14	7	0	58	64	30,03	71	0,048	W	1	Cloudy.
	2	0	69	66	30,10	50		W	1	Cloudy.
15	7	0	60	65	30,19	63		W	1	Fair.
	2	0	75,5	66	30,19	50		W	1	Fair.
16	7	0	63	65,5	30,07	59		SW	1	Fine.
	2	0	76	69	29,96	50		SSE	1	Fine.

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1792	Time. H.	Time. M.	Therm. without.	Therm. within.	Barom.	Hygrometer.	Rain.	Winds. Points.	Winds. Str.	Weather.
			°	°	Inches.		Inches.			
July 17	7	0	65	67,5	29,69	69	0,220	SW	2	Cloudy.
	2	0	73	68	29,76	51		SW	2	Fair.
18	7	0	58	67	29,77	69		SW	2	Cloudy.
	2	0	71,5	68	29,79	48		SW	2	Fine.
19	7	0	60	66	29,93	62		SW	2	Fair.
	2	0	71,5	67	29,93	49		W	2	Fair.
20	7	0	58	66	29,95	64		W	1	Fair.
	2	0	67	67	29,87	50		E	1	Cloudy.
21	7	0	55	65	29,52	80	0,510	W	2	Cloudy.
	2	0	56	64,5	29,62	79		WNW	1	Rain.
22	7	0	54	64	29,97	66	0,601	WNW	1	Fair.
	2	0	65	64	30,05	60		WNW	1	Fair.
23	7	0	55	63	30,05	58		WNW	1	Cloudy.
	2	0	65	64	30,00	49		E	1	Cloudy.
24	7	0	53	63	29,95	60		E	1	Fair.
	2	0	68	64	29,92	48		E	1	Cloudy.
25	7	0	55	63	29,86	64		SE	1	Cloudy.
	2	0	60	64	29,77	63		SSE	2	Cloudy.
26	7	0	58	63	29,70	68	0,017	SW	1	Fine.
	2	0	71,5	64,5	29,70	47		SW	1	Fair.
27	7	0	58	63,5	29,58	67	0,061	SW	2	Cloudy.
	2	0	64,5	64	29,60	53		SW	2	Cloudy.
28	7	0	55	63,5	29,69	61		SW	1	Fine.
	2	0	71	65	29,71	46		SW	1	Fair.
29	7	0	57	63,5	29,61	67		SSW	1	Rain.
	2	0	60	64	29,52	65		E	1	Cloudy.
30	7	0	55	63	29,87	68	0,261	N	1	Fair.
	2	0	69	65	29,96	51		NW	1	Fair.
31	7	0	55,5	64	30,10	65	0,036	WSW	2	Cloudy.
	2	0	62	64	30,12	63		SSW	2	Cloudy.

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1792	Time. H.	Time. M.	Therm. without. °	Therm. within. °	Barom. Inches.	Hygrometer.	Rain. Inches.	Winds. Points.	Winds. Str.	Weather.
Aug. 1	7	0	62	64	30,30	68		S	1	Cloudy.
	2	0	71,5	68	30,26	53		E	1	Fine.
2	7	0	60	66	30,15	73		E	1	Cloudy.
	2	0	76,5	68,5	30,08	53		E	1	Fine.
3	7	0	65	68	30,00	65		E	1	Fine.
	2	0	76	71,5	29,90	51		E	2	Fine.
4	7	0	63	69	29,99	64		E	1	Fine.
	2	0	75	71,5	30,04	50		E	1	Fine.
5	7	0	60	69	30,17	64		ENE	1	Cloudy.
	2	0	72,5	70,5	30,12	50		NE	1	Fair.
6	7	0	62	69	30,11	67		ENE	1	Cloudy.
	2	0	73	71	30,06	46		E	1	Fine.
7	7	0	61	69	30,06	61		NE	1	Cloudy.
	2	0	72	71	30,11	50		NE	1	Fine.
8	7	0	60	69	30,20	68		E	1	Cloudy.
	2	0	73	70	30,22	53		E	1	Fair.
9	7	0	60	68	30,20	65		E	1	Hazy.
	2	0	78	72	30,17	49		SSE	2	Hazy.
10	7	0	64	69	30,18	59		SSE	2	Cloudy.
	2	0	79	73	30,17	46		SSE	1	Fair.
11	7	0	63	70	30,16	60		SSE	1	Fair.
	2	0	82	73	30,11	45		SSW	1	Fine.
12	7	0	68	70	30,10	53		SW	1	Cloudy.
	2	0	84	74	30,05	45		SW	1	Hazy.
13	7	0	65	72	30,00	62		SW	1	Fine.
	2	0	78	74	29,97	48		SW	1	Fine.
14	7	0	65	72	29,98	55		W	1	Fair.
	2	0	75	73	29 98	48		WNW	1	Fair.
15	7	0	61	71	30,04	58		NW	1	Cloudy.
	2	0	71,5	72	30.04	48		WNW	1	Fine.
16	7	0	61	71	29,85	69	0,031	WNW	1	Cloudy.
	2	0	73	71	29,80	56		WNW	1	Cloudy.

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Aug. 17	7	0	60	71	29.80	63		W	1	Cloudy.
	2	0	73	71	29,79	49		W	1	Cloudy.
18	7	0	59	70	29,52	80	0,400	NE	1	Rain.
	2	0	61	69	29,55	76		NE	1	Rain.
19	7	0	55	68	29,76	69	0,885	NNW	1	Fine.
	2	0	67	68	29.78	51		NW	1	Cloudy.
20	7	0	54	66	29,93	05		NW	1	Fair.
	2	0	65	66	29,90	53		NW	1	Cloudy.
21	7	0	56	65	29,59	77	0,440	SW	2	Rain.
	2	0	70	68	29,53	61		SW	2	Fair.
22	7	0	57	66	29,47	66	0,041	SW	2	Rain.
	2	0	68	67	29,40	53		SW	2	Fair.
23	7	0	57	65	29,41	63		SW	2	Fair.
	2	0	67	66	29,47	53		W	2	Cloudy.
24	7	0	58	65	29,84	68	0,028	W	2	Fair.
	2	0	70	66	29,94	51		W	2	Fair.
25	7	0	58	65	29,93	67	0,075	SW	2	Rain.
	2	0	66,5	66,5	29,87	61		SW	2	Cloudy.
26	7	0	62	66	29,71	72		SW	1	Cloudy.
	2	0	64	67	29,60	70		SSE	2	Rain.
27	7	0	57	66	29,70	63	0,165	WSW	2	Fine.
	2	0	69,5	67	29,80	47		WSW	2	Fine.
28	7	0	54	65	29,91	66		W	1	Fine.
	2	0	68,5	67	29,94	47		ENE	1	Fine.
29	7	0	57	66	30,12	62		NE	1	Cloudy.
	2	0	64	65,5	30,12	55		NE	2	Cloudy.
30	7	0	58	65	29,95	62		NE	1	Cloudy.
	2	0	62	65	29,92	66		E	1	Cloudy.
31	7	0	57	65	30,00	71		E	1	Cloudy.
	2	0	68	65,5	29,98	59		ESE	2	Cloudy.

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1792	Time. H.	Time. M.	Therm. without. °	Therm. within. °	Barom. Inches.	Hygrometer.	Rain. Inches.	Winds. Points.	Winds. Str.	Weather.
Sept. 1	7	o	60	65	29,88	69	0,125	SE	1	Cloudy.
	2	o	62	65,5	29,88	68		SSE	1	Cloudy.
2	7	o	59	65	29,90	71	0,068	SSE	1	Fine.
	2	o	69	66	29,90	55		SSE	2	Fair.
3	7	o	57	65	29,81	70		SSE	1	Cloudy.
	2	o	66,5	65,5	29,77	60		SSW	1	Fair.
4	7	o	54	64,5	29,60	67	0,052	WSW	1	Fair.
	2	o	67,5	65	29,60	56		SW	1	Cloudy.
5	7	o	49	64	29,74	70		SW	1	Foggy.
	2	o	66,5	65	29,84	54		WSW	1	Fair.
6	7	o	54	64	30,13	70		NNE	1	Foggy.
	2	o	67,5	65	30,15	58		SSE	1	Fair.
7	7	o	57	64	30,14	67		WSW	1	Cloudy.
	2	o	65	64,5	30,08	62		WSW	1	Cloudy.
8	7	o	60	64	29,95	72		WSW	1	Cloudy.
	2	o	65	65	29,95	61		WSW	1	Cloudy.
9	7	o	53	63	30,00	67		NW	1	Cloudy.
	2	o	61	64	29,98	58		W	1	Cloudy.
10	7	o	60	63,5	29,70	66		WSW	2	Cloudy.
	2	o	65	65	29,76	48		WNW	2	Fair.
11	7	o	49	63	29,81	62		WNW	2	Fine.
	2	o	57	63	29,90	57		WNW	1	Fair.
12	7	o	49,5	62	30,08	63	0,030	WNW	1	Cloudy.
	2	o	56	62	29,84	67		WSW	2	Rain.
13	7	o	53	61	29,62	62	0,172	WSW	2	Fine.
	2	o	63	62	29,70	51		WNW	2	Fair.
14	7	o	51	61	29,89	68		WNW	1	Cloudy.
	2	o	57	61	29,74	74		WNW	1	Rain.
15	7	o	45	59,5	30,03	70	0,493	NW	2	Cloudy.
	2	o	53	60	30,19	51		NNW	2	Fine.
16	7	o	43	59	30,34	64		N	1	Fine.
	2	o	56,5	59,5	30,34	55		WNW	1	Fine.

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1792	Time. H.	Time. M.	Therm. without. °	Therm. within. °	Barom. Inches.	Hygrometer.	Rain. Inches.	Winds. Points.	Winds. Str.	Weather.
Sep. 17	7	0	48	59	30,17	61		W	1	Cloudy.
	2	0	57	59	30,11	57		SSW	1	Cloudy.
18	7	0	47,5	58	30,01	71	0,030	SSW	1	Cloudy.
	2	0	60	59	29,95	59		SSW	1	Cloudy.
19	7	0	57	59	29,87	74		SW	2	Cloudy.
	2	0	60	60	29,78	67		SSW	2	Cloudy.
20	7	0	48	59	29,52	73	0,213	W	1	Fine.
	2	0	52	59,5	29,40	65		WSW	2	Rain.
21	7	0	43	57,5	29,38	69	0,280	WSW	2	Fine.
	2	0	52	58	29,24	63		WSW	2	Rain.
22	7	0	44	56,5	29,09	68	0,072	W	2	Fine.
	2	0	54	58	29,24	60		WNW	2	Rain.
23	7	0	42	56	29,47	70	0,043	NW	1	Fine.
	2	0	53	57	29,57	63		WNW	1	Cloudy.
24	7	0	47	55,5	29,62	69	0,017	W	2	Rain.
	2	0	54	57	29,45	70		S	2	Cloudy.
25	7	0	48	55,5	29,33	66	0,014	W	2	Cloudy.
	2	0	54	56	29,54	65		NW	2	Cloudy.
26	7	0	45	55	30,02	70	0,023	WNW	1	Fine.
	2	0	56	57	30,06	55		NW	1	Fair.
27	7	0	47	55,5	30,07	65		NNW	1	Cloudy.
	2	0	57	56,5	30,00	56		NNW	1	Cloudy.
28	7	0	54	56	29,73	78	0,040	SW	2	Cloudy.
	2	0	56,5	57	29,58	72		SSW	2	Cloudy.
29	7	0	50	56,5	29,47	74	0,071	SSW	1	Fine.
	2	0	53	57	29,44	70		S	2	Rain.
30	7	0	56	57,5	29,40	81	0,167	E	1	Cloudy.
	2	0	62	58	29,49	67		E	1	Cloudy.

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1792	Time. H.	Time. M.	Therm. without. °	Therm. within. °	Barom. Inches.	Hygrometer.	Rain. Inches.	Winds. Points.	Winds. Str.	Weather.
Oct. 1	7	0	56	58	29,62	78	0,020	E	1	Fair.
	2	0	63	60	29,63	68		E	1	Cloudy.
2	7	0	56	59	29,73	80	0,043	ENE	1	Cloudy.
	2	0	57	59,5	29,70	70		NE	1	Cloudy.
3	7	0	53	59	29,80	67		ENE	2	Cloudy.
	2	0	52	58	29,83	65		ENE	2	Cloudy.
4	7	0	47	57	29,88	64		ENE	1	Cloudy.
	2	0	49	56,5	29,82	62		ENE	1	Cloudy.
5	7	0	47	57	29,74	67		E	1	Cloudy.
	2	0	50	58	29,73	63		ENE	1	Cloudy.
6	7	0	49	57	29,71	73		ENE	1	Cloudy.
	2	0	52	59	29,72	70		NE	2	Cloudy.
7	7	0	48,5	57	29,78	73	0,028	NNE	1	Cloudy.
	2	0	52	59	29,80	63		E	1	Cloudy.
8	7	0	47,5	56,5	29,85	64		NE	1	Cloudy.
	2	0	52	58,5	29,85	59		NE	1	Cloudy.
9	7	0	46,5	56,5	29,80	64		NE	1	Cloudy.
	2	0	52	58	29,78	60		NNE	1	Cloudy.
10	7	0	46	56,5	29,76	77	0,062	N	1	Rain.
	2	0	49	58	29,76	79		N	1	Rain.
11	7	0	43	57	29,83	74	0,507	NW	1	Fine.
	2	0	53	58	29,87	62		NW	1	Fair.
12	7	0	40	56	29,76	73		WNW	1	Cloudy.
	2	0	53	58	29,59	62		S	2	Cloudy.
13	7	0	44	56	29,46	68		SSW	1	Fair.
	2	0	54	58	29,39	68		SSE	2	Cloudy.
14	7	0	52	56,5	29,26	81	0,383	S	2	Rain.
	2	0	52,5	59	29,29	68		SW	2	Cloudy.
15	7	0	52	58	29,38	76	0,168	SSW	2	Rain.
	2	0	55	59,5	29,36	69		SSW	2	Cloudy.
16	7	0	48	58	29,68	71	0,135	SW	1	Cloudy.
	2	0	53	59	29,63	67		SW	2	Cloudy.

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Oct. 17	7	0	46	58	29,78	73	0,130	WSW	1	Fair.
	2	0	55	60	29,76	67		SW	2	Fair.
18	7	0	43	58	29,67	69		WSW	2	Fine.
	2	0	53	60	29,77	58		W	1	Fair.
19	7	0	39	57	29,95	71		W	1	Fair.
	2	0	50	58,5	29,95	58		W	1	Hazy.
20	7	0	53	58	29,71	77		S	2	Cloudy.
	2	0	57	59	29,65	72		SSW	2	Cloudy.
21	7	0	51	58,5	29,58	81	0,025	S	1	Fine.
	2	0	56	60	29,54	74		SSE	2	Cloudy.
22	7	0	52	59	29,68	76	0,068	SSE	2	Fair.
	2	0	58,5	61,5	29,78	64		SSW	2	Fair.
23	7	0	48	59,5	30,05	71		SSW	2	Fine.
	2	0	56,5	61	30,11	66		SSW	1	Cloudy.
24	7	0	42	59	30,37	68		WSW	1	Cloudy.
	2	0	51	59,5	30,42	63		NE	1	Cloudy.
25	7	0	42	57,5	30,32	67		NE	1	Cloudy.
	2	0	50	58,5	30,30	67		NE	1	Cloudy.
26	7	0	44	56	30,12	66		ENE	1	Cloudy.
	2	0	47,5	57,5	30,00	63		E	2	Cloudy.
27	7	0	48	56	29,93	74		E	1	Cloudy.
	2	0	58	59	29,96	71		ESE	1	Cloudy.
28	7	0	54	57,5	29,90	83		SE	1	Cloudy.
	2	0	58	60	29,92	73		SSE	1	Fair.
29	7	0	52	58	29,90	84		W	1	Cloudy.
	2	0	58	60	29,93	71		W	1	Cloudy.
30	7	0	48	58	29,95	77		W	1	Cloudy.
	2	0	54,5	59,5	29,82	77		SW	2	Cloudy.
31	7	0	53	59	29,48	80	0,315	WSW	1	Cloudy.
	2	0	57	61	29,61	60		W	1	Fair.

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1792	Time. H.	Time. M.	Therm. without.	Therm. within.	Barom.	Hygrometer.	Rain.	Winds. Points.	Winds. Str.	Weather.
			o	o	Inches.		Inches.			
Nov. 1	7	o	48	59	29,82	70	0,035	W	2	Fair.
	2	o	52	59,5	29,75	70		SSW	2	Cloudy.
2	7	o	42	58	30,00	68	0,080	WNW	1	Fine.
	2	o	50,5	61	30,14	63		WNW	1	Fine.
3	7	o	59	59	30,19	84		W	1	Cloudy.
	2	o	58	62	30,20	63		SW	1	Fine.
4	7	o	47	60	30,16	75		SW	1	Fine.
	2	o	55,5	63,5	30,17	69		SSW	1	Fine.
5	7	o	42	60	30,22	73		SSW	1	Foggy.
	2	o	50	60,5	30,25	77		SSW	1	Foggy.
6	7	o	39	58	30,25	77				Foggy.
	2	o	46	59,5	30,24	79				Foggy.
7	7	o	46	58,5	30,24	75		SSW	1	Cloudy.
	2	o	49,5	58,5	30,27	70		SSW	1	Cloudy.
8	7	o	49	58,5	30,41	70		SSW	1	Cloudy.
	2	o	52	59	30,44	64		SSW	1	Cloudy.
9	7	o	49	59	30,40	67		SSW	1	Cloudy.
	2	o	53	59	30,32	68		SSW	1	Cloudy.
10	7	o	49,5	58	30,24	71		SSW	1	Cloudy.
	2	o	53	59,5	30,24	66		SSW	1	Cloudy.
11	7	o	49	59	30,22	76		SSW	1	Cloudy.
	2	o	50	60	30,17	70		SSW	1	Cloudy.
12	7	o	42	57	29,92	70		E	1	Cloudy.
	2	o	50	60	29,78	67		ESE	1	Fine.
13	7	o	48	58	29,47	73		E	1	Cloudy.
	2	o	52	59,5	29,44	65		S	2	Cloudy.
14	7	o	46	57	29,32	71	0,066	S	2	Rain.
	2	o	52	58,5	29,36	63		SSW	2	Cloudy.
15	7	o	44	57,5	29,64	72		WSW	2	Cloudy.
	2	o	49	58	29,73	59		W	1	Fair.
16	7	o	39	56	29,88	66		WNW	1	Fine.
	2	o	46	57,5	29,94	64		WNW	1	Fair.

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Nov. 17	7	0	34	54,5	30,10	67		NW	1	Fine.
	2	0	40	57	30,18	63		NW	1	Fine.
18	7	0	33	53,5	30,27	67		NW	1	Fair.
	2	0	44	56,5	30,16	65		W	1	Cloudy.
19	7	0	48	54	29,88	67		W	1	Cloudy.
	2	0	50	57	29,95	60		W	1	Fair.
20	7	0	35	55	30,42	64		NW	1	Foggy.
	2	0	40	55	30,43	63		WNW	1	Cloudy.
21	7	0	48	54	30,00	78		WSW	2	Cloudy.
	2	0	52	55,5	29,78	73		SW	2	Cloudy.
22	7	0	41	54	29,64	68	0,183	WNW	1	Fine.
	2	0	46	55,5	29,60	63		NW	2	Fine.
23	7	0	38	54,5	29,80	66		NNW	2	Fine.
	2	0	45	55	29,83	68		NNW	2	Cloudy.
24	7	0	39	54	30,26	72	0,090	NE	1	Cloudy.
	2	0	46	57	30,27	66		NE	1	Cloudy.
25	7	0	41	53	30,24	65		NE	1	Fine.
	2	0	47	55,5	30,14	66		NE	2	Cloudy.
26	7	0	39	53,5	29,93	70		NE	1	Cloudy.
	2	0	43,5	55,5	29,84	71		NE	1	Cloudy.
27	7	0	42	53	29,83	71		NE	1	Cloudy.
	2	0	45	54,5	29,83	66		NE	1	Cloudy.
28	7	0	39	53	29,95	72		E	1	Foggy.
	2	0	41	55	29,92	73		E	1	Cloudy.
29	7	0	38	52	29,91	68		E	1	Fine.
	2	0	43	54	29,95	66		E	1	Fine.
30	7	0	38	52	30,05	72		E	1	Cloudy.
	2	0	37,5	53	30,00	70		ESE	1	Cloudy.

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Dec. 1	8	0	34	50	29,85	70		E	1	Cloudy.
	2	0	34	51	29,85	69		E	1	Cloudy.
2	8	0	37	50	30,15	69		E	1	Cloudy.
	2	0	38,5	51,5	30,21	69		NE	1	Cloudy.
3	8	0	37	50	30,35	66		E	1	Foggy.
	2	0	35	50,5	30,34	66		W	1	Cloudy.
4	8	0	37	49,5	30,26	78		WNW	1	Foggy.
	2	0	42	51,5	30,11	80		WSW	1	Cloudy.
5	8	0	52	53	29,60	79	0,152	WSW	1	Cloudy.
	2	0	53	55,5	29,56	77		WSW	1	Cloudy.
6	8	0	43	53,5	29,64	73	0,041	SSW	1	Cloudy.
	2	0	50,5	56,5	29,34	70		SW	2	Cloudy.
7	8	0	38,5	53,5	29,67	62	0,097	WNW	2	Fair.
	2	0	39,5	56	29,92	59		NW	2	Fine.
8	8	0	32	52	30,25	73		NW	1	Fine.
	2	0	40	55	30,30	66		NW	1	Fine.
9	8	0	45	53	30,09	66		W	2	Cloudy.
	2	0	49	54,5	29,91	64		W	2	Cloudy.
10	8	0	52	55	29,88	72		W	2	Cloudy.
	2	0	53,5	57	29,85	68		W	2	Cloudy.
11	8	0	44	55	30,00	63		W	2	Cloudy.
	2	0	45,5	57	30,00	60		WNW	2	Fair.
12	8	0	37	54	30,27	62		WNW	1	Fair.
	2	0	42	55,5	30,25	63		NW	1	Cloudy.
13	8	0	38	53	29,68	78	0,302	ENE	1	Cloudy.
	2	0	39	55	29,72	75		NE	1	Cloudy.
14	8	0	49	54	29,76	70	0,162	WNW	1	Cloudy.
	2	0	50	57	29,80	65		WNW	1	Cloudy.
15	8	0	45	55	29,90	68		NW	1	Fair.
	2	0	49	58	29,93	65		NW	1	Fair.
16	8	0	39	55	30,22	73		ENE	1	Cloudy.
	2	0	43	57	30,24	68		ENE	1	Cloudy.

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Dec. 17	8	0	42	54	30,17	78		S	1	Cloudy.
	2	0	48	57	30,10	73		SW	2	Cloudy.
18	8	0	48	56	29,85	76		WSW	2	Cloudy.
	2	0	51,5	59	29,82	76		W	2	Cloudy.
19	8	0	49	57,5	29,80	67		WNW	2	Fair.
	2	0	51	59	30,00	58		WNW	2	Fine.
20	8	0	52	58	29,73	78		SW	2	Cloudy.
	2	0	53	60	29,64	74		W	2	Cloudy.
21	8	0	38	56	29,71	66	0,103	NW	2	Fine.
	2	0	43	59	29,87	61		NW	2	Fine.
22	8	0	45	55	29,58	74	0,051	SW	2	Cloudy.
	2	0	45	57	29,22	67		SW	2	Fair.
23	8	0	34,5	54	29,45	60	0,095	N	2	Fine.
	2	0	33	56	29,58	55		N	2	Fine.
24	8	0	31,5	51,5	29,78	63		NNW	2	Fair.
	2	0	34,5	54	29,79	63		NNW	2	Fair.
25	8	0	32	51	29,54	75		NW	1	Foggy.
	2	0	38	52	29,51	72		WNW	1	Cloudy.
26	8	0	37	51	29,00	77	0,348	WNW	1	Cloudy.
	2	0	36	53	29,00	77		WNW	1	Snow.
27	8	0	36	51	29,48	77	0,177	WNW	1	Cloudy.
	2	0	39	53	29,56	70		NW	1	Cloudy.
28	8	0	36,5	50	29,61	72	0,020	NW	1	Fair.
	2	0	41	53	29,71	67		NW	1	Fine.
29	8	0	41	51	29,88	79	0,103	WSW	1	Cloudy.
	2	0	47	53	29,85	81		WSW	1	Cloudy.
30	8	0	44	52	29,86	77	0,115	W	1	Cloudy.
	2	0	45	55,5	29,95	68		WNW	1	Fine.
31	8	0	32,5	51	30,27	72		NW	1	Cloudy.
	2	0	33,5	54	30,27	73		WNW	1	Hazy.

1792.	Thermometer without.			Thermometer within.			Barometer.			Hygrometer.			Rain.
	Greatest height.	Least height.	Mean height.	Greatest height.	Least height.	Mean height.	Greatest height.	Least height.	Mean height.	Greatest height.	Least height.	Mean height.	
	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.	Inches.	Inches.	Inches.				Inches.
January	53	19	37,2	57,5	43	51,1	30,47	28,94	29,66				1,810
February	56	16,5	40,0	60	43	52,6	30,40	29,53	29,98				0,712
March	56	26	44,3	61	46	54,3	30,51	29,07	29,77	85	48	64,3	1,791
April	66	38	52,0	65,5	54,5	59,3	30,32	29,12	29,90	75	44	59,6	1,550
May	67	42,5	53,3	63	54	58,2	30,39	29,32	29,97	72	43	56,7	1,624
June	79,5	49	58,1	65	59,5	61,6	30,27	29,41	29,93	67	40	57,7	1,624
July	76	53	61,7	69	63	64,8	30,19	29,52	29,88	80	46	60,9	2,299
August	84	54	65,7	74	64	68,5	30,30	29,40	29,93	80	45	59,1	2,065
September	69	42	55,1	65,5	55	60,5	30,34	29,09	29,79	81	48	60,5	1,910
October	63	39	51,0	61,5	56	58,3	30,42	29,26	29,79	84	58	69,8	1,884
November	58	35	45,5	63,5	52	56,9	30,44	29,32	30,02	84	59	68,9	0,454
December	53	31,5	41,9	60	49,5	54,2	30,35	29,00	29,85	81	58	69,9	1,766
Whole year			50,5			58,4			29,87				19,489

PHILOSOPHICAL TRANSACTIONS

OF THE

ROYAL SOCIETY

OF

LONDON,

FOR THE YEAR MDCCXCIII.

PART II.

LONDON.

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MDCCXCIII.